Arnold Schwarzenegger
Governor

AIR QUALITY IMPLICATIONS OF BACKUP GENERATORS IN CALIFORNIA

VOLUME ONE: GENERATION SCENARIOS, EMISSIONS AND ATMOSPHERIC MODELING, AND HEALTH RISK ANALYSIS

PIER FINAL PROJECT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
**University of California, Riverside
Bourns College of Engineering—Center for Environmental Research and Technology (CE-CERT)**

March 2005
CEC-500-2005-048

Prepared By:
University of California, Riverside
Bourns College of Engineering—Center for Environmental Research and Technology (CE-CERT)
James M. Lents, Principal Investigator
Lisa Arth
Mitch Boretz
Mark Chitjian
Kathy Cocker
Nicole Davis
Kent Johnson
Yuan Long
J. Wayne Miller
Ulises Mondragon
R.M. "Nick" Nikkila
Mohammad Omary
Don Pacocha
Youjun Qin
Sandip Shah
Gail Tonnesen
Zion S. Wang
Michel Wehrey
Xiaona Zhu

Contract No. 500-00-032

Prepared For:
California Energy Commission
Public Interest Energy Research (PIER) Program

Marla Mueller,
Contract Manager

Kelly Birkinshaw,
Program Area Team Lead

Ron Kukulka,
Acting Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Robert L. Therkelsen
Executive Director

DISCLAIMER
This report was prepared as the result of work sponsored by the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees or the State of California. The Energy Commission, the State of California, its employees, contractors and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the California Energy Commission nor has the California Energy Commission passed upon the accuracy or adequacy of the information in this report.

Please cite this report as follows:

J. M. Lents, L. Arth, M. Boretz, M. Chitjian, K. Cocker, N. Davis, K. Johnson, Y. Long, J. W. Miller, U. Mondragon, R. M. Nikkila, M. Omary, D. Pacocha, Y. Qin, S. Shah, G. Tonnesen, Z. S. Wang, M. Wehrey, X. Zhu. 2004. *Air Quality Implications of Backup Generators in California – Volume One: Generation Scenarios, Emissions and Atmospheric Modeling, and Health Risk Analysis.* California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-048.

Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies

What follows is the final report for the project titled, "A Study of Peak-Load Energy Production Potential and Air Quality Impacts of Backup Generators (BUGs)," contract number 500-00-032, conducted by the University of California, Riverside Bourns College of Engineering—Center for Environmental Research and Technology (CE-CERT). The report is entitled *Air Quality Implications of Backup Generators in California – Volume One: Generation Scenarios, Emissions and Atmospheric Modeling, and Health Risk Analysis.* This project contributes to the PIER Energy-Related Environmental Research program.

For more information on the PIER Program, please visit the Energy Commission's Web site www.energy.ca.gov/pier/ or contract the Energy Commission at (916) 654-4628.

Table of Contents

List of Figures

List of Tables

Abstract

Results of this project's work is presented in two volumes. Volume I reviews the use of diesel-fueled backup generators (BUGs) during California's 2001 electricity blackouts, considers the policy and regulatory issues related to expanded use of diesel-fueled BUGs, estimates impacts on air quality and health associated with extensive use of presently configured diesel-fueled BUGs, and recommends emission factors to estimate emissions from diesel-fueled BUGs. Volume II reviews the emission tests of a broad range of diesel-fueled BUGs and the impact of potential control scenarios.

During the 2001 California blackouts, diesel-fueled BUGs supplied 18.8% (1537 megawatts) of power reduction needs. This amount was less than expected. Both federal and state air quality authorities provide guidance that diesel-fueled BUGs should only be used as a last resort, and while the governor has broad authority to allow polluting sources to operate during periods of emergency, there is a specified federal procedure that should be followed.

Modeling the impact of diesel-fueled BUG operation indicated that ozone levels were likely to be reduced near the operation of generators but increased downwind. Exposure to diesel particulate from the use of diesel-fueled BUGs can produce cancer risks greater than 10 in one million, which many regulatory agencies consider unacceptable.

Measurement of emissions from diesel-fueled BUGs determined that the present federal (EPA) emission factors for these generators project higher emissions than is actually occurring and should be modified.

Key Words: backup generator, BUG, diesel generator, diesel generator impact, diesel generator emissions, electricity blackout, diesel engine emission factor, emission factor, diesel, California blackout

Executive Summary

Introduction

This report describes results of three projects conducted by the University of California, Riverside, Bourns College of Engineering-Center for Environmental Research and Technology (CE-CERT) under California Energy Commission agreement 500-00-032, "A Study of Peak-Load Energy Production Potential and Air Quality Impacts of Backup Generators (BUGs)." The projects addressed:

- Electricity generation scenarios (Section 1)
- Policy and regulatory issues (Section 2)
- Atmospheric modeling (Section 3)
- Health risk assessment (Section 4)

This report combines these different efforts into a single report, because they are closely related to one another.

Volume II of this report contains all results from measurement of emissions from uncontrolled (baseline) backup generators, and the same units with reformulated fuels and/or emission control technologies.

Purpose

The project's overall purpose is to develop model scenarios and data sets that can be used to evaluate air quality impacts of BUGs. To a lesser extent, other distributed generation (DG) technologies that are expected to account for a meaningful portion of the future electricity supply also are within the scope of the study.

Project Objective

Specifically, the project's objective is to implement methodologies to provide quantifiable, objective data for decision makers concerning:

- Potential adverse air quality impacts of the use of significant numbers of BUGs
- Techniques to mitigate likely air quality impacts associated with the use of large numbers of BUGs and their effectiveness and durability in reducing emissions over time
- Ways to facilitate and encourage the implementation of technologies and strategies to reduce BUG air emissions
- Ways to effectively dispatch these units to address electricity demands and environmental concerns

Project Outcomes and Conclusions

Much of the material in this report was presented to the project Steering Committee at a meeting in Sacramento on February 13, 2003. Major conclusions from the research conducted to date include:

- Significant variables affecting emissions from BUGs are: engine type (2-stroke or 4-stroke), model, size, operating load, and measurement method.
- Particulate measurements using California Air Resources Board Method 5 are approximately three times higher than measurements using the ISO 8178 methodology.
- Particulate emissions from BUGs are about 80% lower than the values used in the U.S. Environmental Protection Agency's AP-42 model. Newer engines generally show lower emissions than older engines, reflecting tighter emission standards.
- Preliminary results from the use of water-emulsified diesel fuel and a diesel oxidation catalyst show reductions in emissions, but the degree of reduction is not consistent among different engine types and ages.
- BUGs owned and operated by electricity customers with interruptible service agreements are more than 50% larger than BUGs owned and operated by customers with non-interruptible service (948 kilowatts (kW) vs. 615 kW).
- For the May 8, 2001, electricity outage, we calculate that a total of 374 BUGs were operated as a direct consequence of the demand reduction. They generated an overall total of 1537 megawatt-hours (MWh) of electricity, and thus accommodated 18.8% of the required demand reduction.
- Emissions from BUGs during the May 8, 2001, outage are estimated to be 14.88 tons of nitrogen oxides (NO_X), 0.34 tons of sulfur dioxide (SO_2), 0.38 tons of particulate matter (PM_{10}), 1,246 tons of carbon dioxide (CO_2), 2.56 tons of carbon monoxide (CO), and 0.07 tons of volatile organic compounds (VOC).
- Modeling of exposure to particulate matter as a result of hypothetical BUGs operation found that all scenarios for both large and medium BUGs produce maximum cancer risks greater than 10 in a million—a common regulatory limit for permitting decisions.
- Figure ES-1 shows that the non-white population is 13% higher in block groups surrounding BUGs as compared to the State as a whole. Gender distribution is approximately the same; however, there is a 25% decrease in those under 18 years old and a 15% increase in those over 65 year old in block groups surrounding BUGs, as compared to the State as a whole.
- Direct mortality from exposure to $PM_{2.5}$ from BUGs was not estimated because of the lack of consensus on estimates of the direct mortality risk associated with $PM_{2.5}$. However, it is possible that direct mortality risks could be a significant concern.
- Air quality modeling for ozone (O_3) indicates that NO_X emissions from BUGs can have a substantial impact on air quality, with reductions in O_3 near the BUGs source but increases in O_3 further downwind. Ozone levels decreased by 10 parts per billion (ppb) or more near the source because of NO titration of O_3 and NO_2 scavenging of hydroxyl free radicals, but O_3 levels increased downwind because the transported NO_X caused greater O_3 production. We present results using three different air quality models and for four different model scenarios. The models and the scenarios used are described in Section 3.1. Figure ES-2 shows example results of BUGs effects on O_3 for the four modeling studies:

- Figure ES-2a is an example plot showing the effects of the 8-hour BUGs deployment scenario for the SARMAP Air quality model for a 1990 O_3 study in Central California.
- Figure ES-2b shows an example result for the CAMx air quality model for a 2000 O_3 study in Central California.
- Figure ES-2c shows an example result for the U.S. Environmental Protection Agency's CMAQ air quality model for a 1997 O_3 study in southern California.
- Finally, ES-2d shows an example result for the EPA's CMAQ air quality model for a 1996 PM study in the western United States.

Figure ES-2 shows that the results are generally quite consistent among the four studies. The 1990 SAQM modeling shows larger effects of BUGs emissions, because we used the AP-42 emissions factors for BUGs emissions; whereas in the other three modeling studies we used lower NO_X emissions factors, based on the results of the BUG emissions testing conducted as part of this project. Figure ES-2c shows smaller effects of BUGs on O_3 because it used the reduced number of BUGs for the blackout incident. The generally consistent effects on O_3 for these four studies suggests that these results should be fairly robust in spite of uncertainty in particular models or episodes.

- Air quality modeling for aerosols showed increases in $PM_{2.5}$ as much as 3.3 $\mu g/m^3$. (Figure ES-2). Approximately two-thirds of the increase in $PM_{2.5}$ was from aerosol nitrate (Figure ES-3). The NO_X disbenefit for $PM_{2.5}$ is much less than that for O_3, because the mechanism responsible for the O_3 reduction causes direct production of HNO_3 followed by production of aerosol nitrate.

Figure ES-1. Comparison of breakdown for California as a whole to the U.S. census block group data surrounding a BUG, based on gender and age (top) and based on ethnic group (bottom)

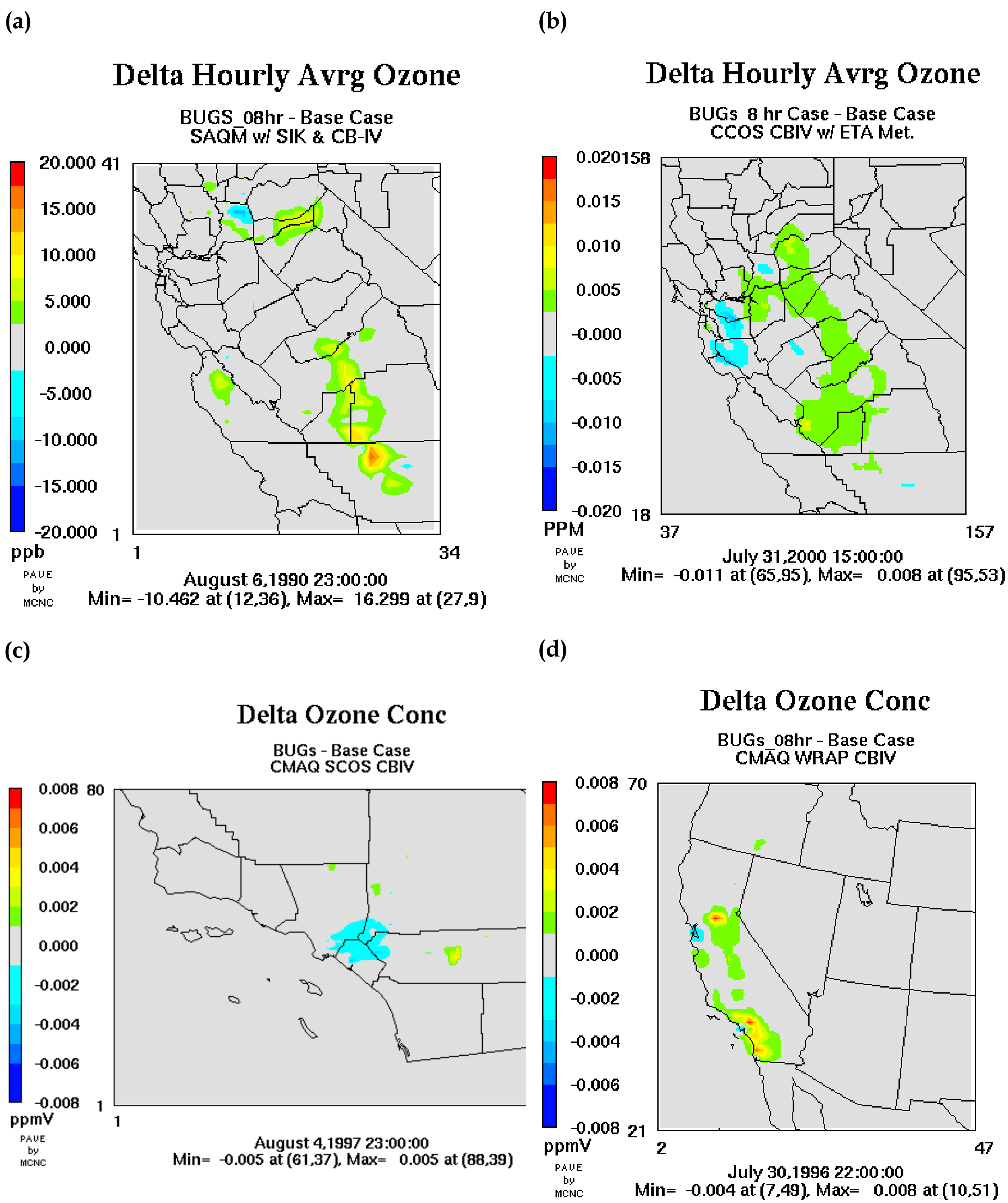


Figure ES-2. Comparison of effects of BUGs emissions on O_3 using 4 different model scenarios: (a) 1990 SAQM model, 8-hour operation; (b) 2000 CAMx model with 8-hour operation; (c) 1997 CMAQ model for the Blackout scenario; and (d) 1996 WRAP CMAQ model using 8-hour BUGs operation. (Note that (a) is in units of parts per billion (ppb), while the other plots are parts per million (ppm).)

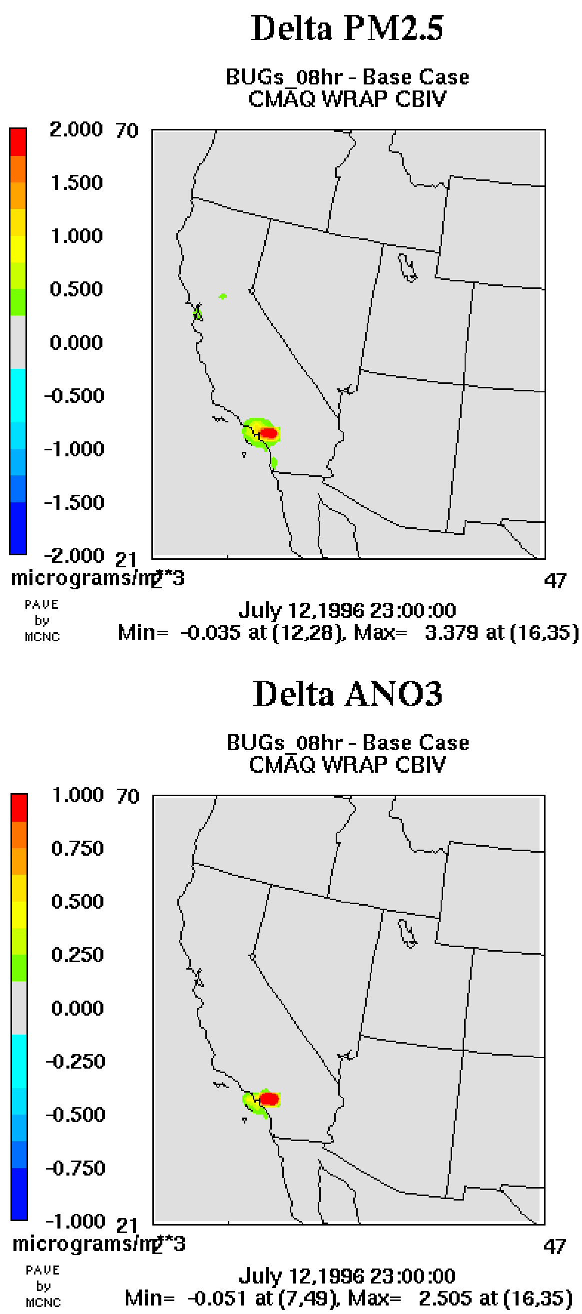


Figure ES-3. Effects of BUGs emissions for 8-hour operation in the WRAP 1996 model scenario on $PM_{2.5}$ (top) and aerosol nitrate (bottom). The largest increases are 3.38 µg/m^3 in $PM_{2.5}$ and 2.50 µg/m^3 for aerosol nitrate (ANO_3).

Recommendations and Benefits to California

This study demonstrated that the use of backup generators during electricity curtailments were smaller than expected and that modern diesel-fueled generators pollute less than predicted by presently available emission factors. Thus, the use of diesel-fueled generators at the present rate and extent of electricity curtailments should not pose a threat to public health, except in rare cases where a generator may be located in an enclosed area near sensitive populations.

The study noted that there are federally defined procedures which should be followed by California officials if there is a need to suspend air quality regulations during a public emergency and that care should be taken to adhere to those procedures.

Emissions from diesel-fueled generators—even modern ones—are of a nature and high enough without add-on controls that they are not a good option as a source of distributed generation. If there is an interest in using diesel-fueled generators as a source of base power, then particulate and nitrogen oxide (NO_X) controls should be added and carefully maintained. Otherwise, the public health and welfare could potentially be compromised.

The study demonstrated that there are options for particulate control for modern diesel-fueled generators that are very effective at reducing emissions and that older diesel-fueled generators can be partially controlled through the use of oxidation catalyst and water-emulsified fuels.

1. Electricity Generation Scenarios

The purpose of this chapter is to develop information concerning the power outages that occurred in 2001. This information is necessary to properly evaluate potential environmental impacts of future power outages.

The most significant outages occurred on March 19, March 20, May 7, and May 8, 2001. We examined the May 8 event to determine the degree to which BUGs were used and the environmental impacts of these operations. The purpose of the review was to develop needed input for ambient air quality modeling. Inputs sought included number and size of BUGs operated, duration of operation, operating load, and spatial coordinates of BUGs that were operated. With this information, modeling could yield an estimate of the air quality impact associated with BUGs usage during an actual rolling blackout.

1.1. Introduction

The 2001 statewide inventory of emergency backup generators[1] (BUGs) indicates there are some 4100 BUGs with a generating capacity of 300 kilowatt (kW) or greater within the state of California. From an energy standpoint, these BUGs, in total, have the potential to generate 3,200 MW of electricity. From an environmental perspective, these BUGs have the potential to emit 706 tons of nitrogen oxides (NO_X), 15 tons of sulfur dioxides (SO_2), 18 tons of particulate matter (PM_{10}), 58,575 tons of carbon dioxide (CO_2), 122 tons of carbon monoxide (CO), and 4 tons of volatile organic compounds (VOC) per day.[2]

During 2001, there were a number of occasions when peak energy demand exceeded energy production and/or transmission capabilities. As a result, the office of the California Independent Service Operator (Cal-ISO) ordered selected utilities to reduce electrical load within their individual customer groups by assigned amounts. This resulted in what were termed as "rolling blackouts," in which power to different consumers' transmission lines was curtailed during each Cal-ISO-ordered demand reduction. Significant rolling blackouts occurred on four occasions during 2001—March 19, March 20, May 7, and May 8 (Cal-ISO Web site 10/17/01).

The magnitude of the potential emissions of pollutants from the operation of BUGs has raised concern about their use during any future Cal-ISO-ordered blackouts. In order to address that concern, the Center for Environmental Research and Technology (CE-CERT), with assistance from NN Environmental Consulting, and Energy and Transportation Solutions, undertook an effort to review the operation of BUGs during one (May 8) of the four most significant outage periods[3] in 2001. May 8 was selected for two reasons: first and foremost, by the time

---

1. A. D. Little. 2001. *Inventory of Backup Generators in the State of California.* California Energy Commission. P500-01-027. www.energy.ca.gov/reports/2002-02-15_500-01-027.PDF

2. These figures are based on an analysis by Nicole Davis of CE-CERT's BUG's emission testing results, with the exception of SO_2, which is based upon emission factors developed by Bluestein and Lents (Appendix A).

3. *Significant outage periods* refers to those outages that involved more than one utility and impacted both interruptible and non-interruptible customers.

information on the locations of interruptible service customers became publicly available, the historical outage map data for March 19 and 20 was no longer available. Outage information was available for both May 7 and May 8. Each of those dates were similar in the length and magnitude of the demand reduction; however, on May 8, Southern California Edison (SCE) sources represented a greater portion of the load reduction. Since the determination of the number of BUGs operating within the other utilities' service districts would be extrapolated from the SCE data, it was felt that May 8 would be the better choice.

The purpose of the review was to develop needed input for ambient air quality modeling. Inputs sought included: number and size of BUGs operated, duration of their operation, operating load, and spatial coordinates of BUGs that were operated. With this information, modeling could yield an estimate of the air quality impact associated with BUGs usage during an actual rolling blackout.

During the course of the review, the only publicly available blackout information was from SCE. Thus, survey-based determinations could only be made in their service areas. Impacts in regions outside of the SCE area had to be estimated based on extrapolations derived from the SCE analysis. These extrapolations use the CEC BUGs database to estimate the number of BUGs in non-SCE regions and then make extrapolations based on SCE use fractions. These extrapolations should provide reasonable estimates of BUGs use during the May 8 power crisis.

Before proceeding further, it may be helpful to provide a basic description of the categories of electrical service customers. The following was provided by SCE but is believed to be, generally, applicable to the other utilities:

1.1.1. Exempt Customers

These customers are exempt from rotating outages. They include the following:

A. Government and other agencies providing essential fire, police, and prison services.

B. Government agencies essential to the national defense.

C. Hospitals.

D. Communication utilities, as they relate to public health, welfare, and security, including telephones.

E. Navigation communication, traffic control, and landing and departure facilities for commercial air and sea operations.

F. Electric utility facilities and supporting fuel and fuel transportation services critical to continuity of electric power system operation.

G. Radio and television broadcasting stations used for broadcasting emergency messages, instructions, and other public information related to the electric curtailment emergency.

H. Water and sewage treatment utilities may request partial or complete rotating outage exemption from electric utilities in times of emergency identified as requiring their service, such as fire fighting.

I. Areas served by networks, at serving utility's discretion.

J. Rail rapid transit systems as necessary to protect public safety, to the extent exempted by the Commission.

K. Customers served at transmission voltages to the extent that: (a) they supply power to the grid in excess of their load at the time of the rotating outage, or (b) their inclusion in rotating outages would jeopardize system integrity.

L. Optional Binding Mandatory Curtailment (OBMC) Program: Any customer, or customers, meeting the following criteria:

> The customer must file an acceptable binding energy and load curtailment plan with the utility. The customer must agree to curtail electric use on the entire circuit by the amount being achieved via rotating outages. The customer's plan must show how reduction on the entire circuit can be achieved in 5 percent increments to the 15 percent level, and show how compliance can be monitored and enforced. The customer must maintain the required reduction during the entire rotating outage period. The required curtailment level is requested prior to commencement of Stage 3. Several customers on a circuit may file a joint binding plan to guarantee the required curtailment from the entire circuit. Each utility shall facilitate communication between customers on a circuit if any customer expressed interest in enrolling in the OBMC program.

M. Limited other customers as necessary to protect public health and safety, to the extent exempted by the Commission.

N. Petroleum refineries, vital ancillary facilities, and other customers in the critical fuels chain of production, to the extent exempted by the Commission.

1.1.2. Interruptible-Service Customers

Also known as "non-firm" customers. These are customers that have agreed to have their electrical line power curtailed for limited periods, at the utility's discretion, in return for reduced electricity rates.

1.1.3. Non-Interruptible-Service Customers

Also known as "firm" customers. These are the majority of customers that agree to purchase electricity from a utility with the expectation that it will be continuously available.

The effort to identify locations where BUGs were operated on May 8, 2001 involved three separate activities: (1) a comparison of blackout areas to known BUG locations, (2) cross-matching of the statewide BUGs inventory with the SCE list of interruptible service customers, and (3) a random check of customers from SCE's complete list of interruptible service customers. Each of these activities is described in subsequent sections of this report.

1.2. The May 8, 2001 Blackout

On May 8, Cal-ISO ordered a total load reduction of 2000 MWh between 1200 and1700 hours. Figure 1-1 illustrates the hour-by-hour power reduction on May 8 from the "firm" (non-interruptible) customer inventory. A reduction of 800 MWh was required from five public and private utilities (Pacific Gas & Electric (PG&E), SCE, San Diego Gas & Electric (SDGE), Pasadena, and Vernon) and the remaining reduction of 1200 MWh was required of the California Department of Water Resources (CDWR). Of the 800 MWh in reductions ordered from the five utilities, SCE was required to reduce 336 MWh (42%), and the other four utilities shared the other 58% of required utility load reductions. CDWR was included in the required reductions due to the large number and energy demand of water pumps used by the agency.

Between 1300 and 1900 hours, Cal-ISO also ordered a total load reduction of 6166 MWh from the "non-firm" customers belonging to SCE, PG&E, and SDGE. Southern California Edison was required to reduce 5725 MWh (93%) of the total load reduction. Table 1-1 presents the Official Cal-ISO load-shedding detail for May 8, showing power reductions for the various utilities and CDWR.

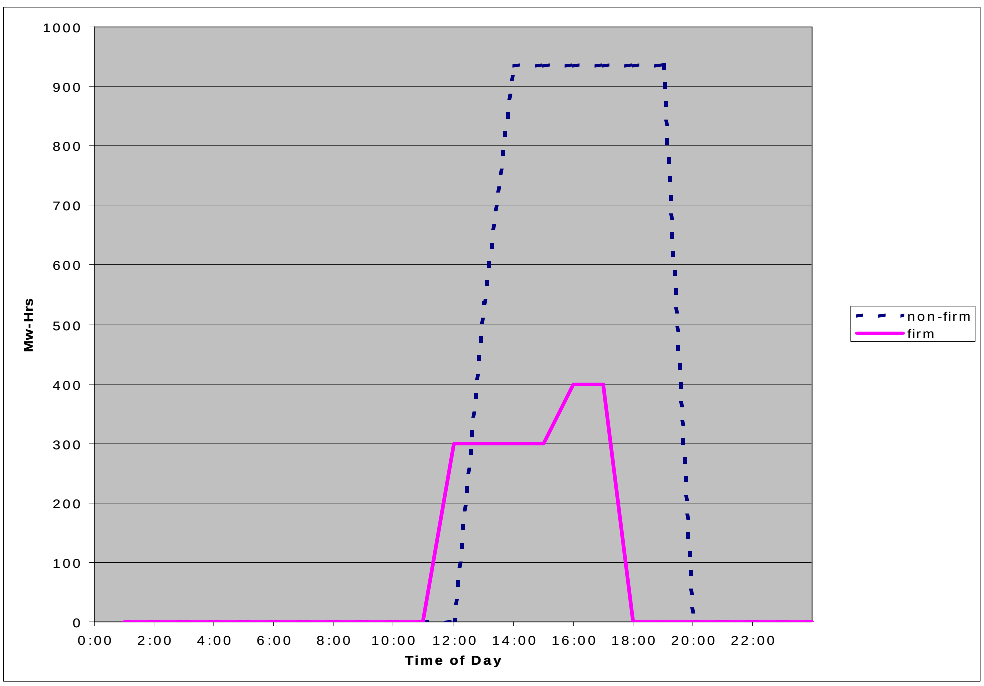


Figure 1-1. Cal-ISO load-shedding by hour on May 8, 2001

Table 1-1. California ISO load-shedding detail for 8-May-01

	Non-Firm				Firm						
Hour Ending	PG&E	SCE	SDGE	ISO Total	PG&E	SCE	SDGE	CDWR	Pasadena	Vernon	ISO Total
0100				0							0
0200				0							0
0300				0							0
0400				0							0
0500				0							0
0600				0							0
0700				0							0
0800				0							0
0900				0							0
1000				0							0
1100				0							0
1200				0				300			300
1300	60	475	3	538				300			300
1400	60	875	3	938				300			300
1500	60	875	3	938				300			300
1600	60	875	3	938	198.4	168	29.6		1.6	2.4	400
1700	60	875	3	938	198.4	168	29.6		1.6	2.4	400
1800	60	875	3	938							0
1900	60	875	3	938							0
2000				0							0
2100				0							0
2200				0							0
2300				0							0
2400				0							0

The exact times and number of megawatts interrupted are approximate and based on information provided by the Utility Distribution Companies.

Prepared by: EO (CAISO) 10/17/2001

The California Department of Water Resources reported that they responded to the ISO order by shutting down water pumps rather than using their BUGs. This was feasible because water supply agencies maintain adequate storage capacity to meet normal water supply needs for a period of time. Had the mandated power curtailment been continued longer, CDWR would likely have been forced to bring their BUGs on line. Clearly, the CDWR had to operate their water pumps to a greater degree than normal after the power curtailment to bring their water reserves back up to appropriate levels. The power generated to provide this added pumping, and the resulting air pollution, would have occurred at the central power plants and thus was not included in this analysis. The use of water resource agencies as a key component of the state power curtailment strategy will help to reduce the impact of BUGs for short duration blackouts. For purposes of this analysis, 60% of the required power reductions were accomplished with no added emissions from BUGs.

1.3. Southern California Load-Shedding by Firm Customers on May 8, 2001

The public information provided by SCE about the load shedding in their district included a table listing the outage date/times, the MW curtailment, and the numbers of the outage groups specific to each curtailment. Southern California Edison public information also included the sets of outage maps in each of the outage groups described in the table. (see Table 1-2)

On May 8, seven outage groups (A025-A030, A032) were affected by the Cal-ISO ordered power curtailment covering a total of 129 sub-regions. Southern California Edison provided maps for each of the 129 sub-regions. The impacted areas are indicated in the SCE load reduction report shown in Table 1-2. The 129 affected sub-regions encompassed parts of 77 incorporated areas, as well as numerous unincorporated areas within three counties. The data in the statewide CEC BUGs inventory was filtered for each of the 77 incorporated areas to establish which BUGs existed in which impacted sub-regions. The unincorporated areas created a slightly increased difficulty. However, with the help of available mapping software, the pertinent zip codes were established and the database filtered for each of the zip codes.

Table 1-2. Southern California load reduction

Historical Rotating Outage Information

Date	Hour Ending	Off Time	On Time	MW	Automated Groups	Nonautomated Groups	Subtrans Groups
05/08/2001	1600 1700	1512 1612	1612 1712	225 163	A25-A28 A29-A30 & A32		
05/07/2001	1700	1648	1748	136	A22-A24		
03/20/2001	1000 1100 1200 1300	0926 1025 1125 1125	1026 1125 1411 1411	200 200 158 158	A21 Counted ACCP Counted ACCP	M05	
03/19/2001	1900	1810	1912	348	A17-A20		
03/19/2001	1300 1300 1400 1400 1500 1600	1200 1235 1256 1335 1433 1530	1257 1337 1355 1435 1530 1615	223 458 447 481 423 373	A01 A02-A05 A06 A07-A11 A12-A16	M01-M04	

Our analysis indicates that 159 (3.9%) of the 4103 BUGs in the California Energy Commission's BUGs inventory were identified as being located within the SCE outage areas for the May 8 event. Information was provided by 80 of the owners/operators. Of those 80, eighteen were apparently sharing a service line with an essential public service (e.g., hospital, fire department) and reported they did not experience the blackouts. Twenty-five are located at a single facility that reported being a participant in SCE's previously described Optional Binding Mandatory Curtailment (OBMC) program and reportedly have not been subjected to blackouts. Of the 37 that reported experiencing blackouts, 16 actually operated their BUGs on May 8. The remaining 21 appear to have experienced the blackout without resorting to on-site power generation. Table 1-3 provides a summary concerning BUGs use in the SCE region during the May 8 power curtailment.

Table 1-3. Summary of BUGs use on May 8, 2001

Region	Number BUGs	Fraction of Total	Of Fraction Surveyed	Of Fraction Receiving Power Curtailment
BUGs in State (Energy Commission Inventory)	4103	100.0%		
Total BUGs in SCE May 8 Power Curtailment Regions	**159**	3.9%		
BUGs at facilities that were successfully contacted	80	1.9%	100.0%	
BUGs at facilities on service line with essential public services (no curtailment)	18	0.4%	22.5%	
BUGs at facility in SCE Optional Binding Mandatory Curtailment (no curtailment)	25	0.6%	31.3%	
BUGs at facilities that were ordered to curtail power	37	0.9%	**46.3%**	100.0%
BUGs at facilities that were ordered to curtail power that actually operated their BUGs on May 8, 2001	16	0.4%		**43.2%**
BUGs at facilities that were ordered to curtail power but did not use their BUGs	21	0.5%		56.8%

Based on the information provided by the 16 sources known to have operated their BUGs, the average duration of BUGs operation was 4.883 hours. The average size of the BUGs placed in operation was 725 kW at an average operating load during the outages of eighty-five percent for an average effective size of 615 kW.

Extrapolating the fractions in Table 1-3 from the eighty BUGs at surveyed facilities to the full 159 BUGs at facilities within the power curtailment regions indicates that a likely total of 46.3% of BUGs or about 73.6 BUGs were at facilities that were ordered to curtail power on May 8. Of these 73.6 BUGs, 43.2% or 32 BUGs likely operated in the SCE curtailment areas during the May 8 event. These data translate to a probable total power generation by BUGs in the SCE area of 96.1 MWh on May 8. Details concerning the calculations are shown in Table 1-4. For extrapolation purposes, the overall load reduction of 96.1 MWh created by BUGs operation equates to 28.6% of the 336 MWh of load reduction Cal-ISO required from SCE. As noted in Figure 1-1 and Table 1-1 above, Cal-ISO required the 336 MWh to occur within a two-hour timespan. BUG operators appear to have started their generating units up prior to the actual outage hours and operated them somewhat beyond those outage hours since they indicated that, on average, they operated their BUGs for 4.88 hours. Thus, for the actual period of the two-hour outage, BUGs only provided 39.4 MW-hours, or 11.7% of the required load reduction for SCE. The remaining power loss was apparently absorbed by other impacted facilities through cutting or modifying their work processes.

Table 1-4. Extrapolation of survey data to SCE curtailment region

Index	Number BUGs	Comment
BUGs in SCE curtailment area	159	Based on analysis of SCE Curtailment Maps
Fraction of BUGs at surveyed facilities where power was ordered to be curtailed.	.463	See Table 1-3
Estimation of BUGs in facilities ordered to curtail power.	73.5	Extrapolation of surveyed facilities to total SCE curtailment region
Fraction of BUGs actually operated at power-curtailed facilities.	.432	See Table 1-3
Estimation of BUGs operated in SCE region during May 8 power curtailment	32	Extrapolation of surveyed facilities to total SCE curtailment region
Average hours BUGs were operated	4.88	Based on survey of facilities operating BUGs
Average power produced by BUGs (kW)	615	Based on survey of facilities operating BUGs
Estimated total power produced by BUGs in SCE region on May 8, 2001 (MWh)	96.0	Extrapolation of surveyed facilities to total SCE curtailment region
Cal-ISO Demand Reduction Required of SCE (MWh)	336.0	From Cal-ISO Historical Record
Percent of demand reduction achieved through overall operation of BUGs	28.6%	Equals 96/336
Percent of demand reduction achieved through operation of BUGs during outage period	11.7%	Equals (0.286/4.88)*2

1.4. Extrapolation of SCE Area Surveys to Other California Regions for Firm Power Customers

Because SCE is apparently the only one of the five utilities to make their power curtailment information publicly available, the only way to estimate BUGs use outside of the SCE area at the present time is to extrapolate the SCE results to the other power curtailment regions. These estimates should be treated as very approximate, but should yield a rough idea of the BUGs operated elsewhere in the state. As noted in Section 1.3, for extrapolation purposes, the operation of BUGs in the SCE region can be calculated to account for 28.6% of the required power reduction from firm power customers. It is not unreasonable that a similar fraction of power would have been absorbed in other regions of California. This is especially true in Southern California where there is a reasonably consistent manufacturing base among the various utilities. Table 1-5 indicates estimated BUGs power generation in various utility areas by assuming that 28.6% of the mandated May 8 power reduction in other utility regions was absorbed by the use of BUGs. The data in Table 1-1 was used to get Cal-ISO mandated power curtailments in each region. The number of BUGs operated within the service territories of these other utilities is determined through back calculation of the estimated BUG power generation using the average hours of operation and average effective size BUG.

Table 1-5. Estimated statewide BUGs operations for May 8, 2001 power curtailment for firm power customers

Utility Region	Power Curtailment (MWh)	Estimated BUGs Generation (MWh)	Estimated Total Number of BUGs Operated on May 8, 2001
Pacific Gas and Electric	396.8	113.5	38
Southern California Edison	336	96.1	32
San Diego Gas and Electric	59.2	16.9	6
California Department of Water Resources	1200	0.0	0
Pasadena	3.2	0.9	0
Vernon	4.8	1.4	0
Total MWh	2000	228.8	76
Actual Total Fraction of Statewide Demand Reduction Attributable to Operation of BUGs: 4.7%			

The results shown in Table 1-5 can be used to estimate total emissions from BUGs operated by "firm" electrical service customers. These emissions must be spatially and temporally segregated to produce data for modeling analysis.

1.5. BUGs Operations by Non-Firm (Interruptible) Service Customers in the SCE Area

As can be noted in Table 1-1 and Figure 1-1, a large fraction of the power reduction on May 8 was achieved through power reductions from non-firm (interruptible-service) utility customers. As discussed earlier, these customers accept a lower power rate in exchange for being first in line to receive power curtailments. Because these customers are the most likely to face power curtailments, it would typically be expected that they would be a high-probability group to own and use BUGs.

During the course of this study, electric utilities were required by state law (Assembly Bill 621, Corbett, Chapter 862, Statutes of 2001) to make their lists of interruptible service customers publicly available. Since the Cal-ISO mandated power reductions included reduction calls for "non-firm" (interruptible-service) as well as "firm" (normal, non-interruptible-service) power contracts, an effort was made to also gather information on the number of interruptible-service related BUGs that operated during the blackout. Initially, a list of the 3410 SCE customers with interruptible ("non-firm") contracts was obtained and matched with the Energy Commission BUGs inventory, by addresses and by entity name. This "sorting" produced a match for 84 BUG owners/operators (2.5% of total). Information was obtained from 44 of these 84 owners/operators. Ten (22.7%) were found to have operated a total of 31 BUGs on May 8, 2001. One other operated their BUG on one or more of the other outage days, but not on May 8, 2001. On average, there were 3.1 BUGs per facility surveyed.

Upon subsequent reflection, it was concluded that the effort to match the statewide BUG inventory with the SCE interruptible-service customer list yielded a statistically insufficient sample. Intuitively, this preliminary finding that only 2.5% of interruptible customers have BUGs seemed small.

In order to improve estimates in this important group of customers, it was decided that a second effort would be made to contact additional interruptible-service customers. In this second approach, a statistically random subset of interruptible customers was contacted to determine if they owned a BUG and if they used it on May 8. Every twentieth customer in SCE's alphabetical database of its interruptible-service customers was selected. This process yielded 171 additional facilities for contact.

Of these 171 facilities, 122 provided useable information. The review indicated 16 of the surveyed groups were private residences and nine were churches. Neither private residences nor churches are likely BUG owners/operators. Instead it was found that these customers believe that they are in a position to simply wait out power curtailments and want to receive the benefits of lower power rates.

Of the other 97 for which information was obtained, 18 reportedly have, or had, generators on May 8. One of the 18 reported having a continuously operated natural gas-fired distributed generation unit, which is not considered for this analysis to be a BUG. The BUGs at two of the other facilities were natural gas or gasoline and were in the size range of 10 kW or less. These BUGs were not counted for the purpose of this study, since the key focus is diesel-fueled BUGs and inclusion of two BUGs of this size would have inappropriately skewed the determination of the average size BUG. This leaves a total of 15 (12.2%) of the 122 surveyed facilities have, or had, diesel-fueled generators on May 8. Of these 15, five facilities (33.3% of those with BUGs) were found to operate a total of eight BUGs (1.6 BUGs per facility) during the May 8 event. Table 1-6 compares the results from the two approaches.

Table 1-6. Comparison of results from the two non-firm customer surveys

	Survey 1	Survey 2		Combined Surveys			
Indicator	**Number**	**Fraction**	**Number**	**Fraction**	**Number**	**Fraction**	**Comment**
Total interruptible customers in SCE area	3410	100%	**3410**	100%	n/a	n/a	Based on SCE provided list
Number of customers that provided information	84	n/a	**122**	3.6%	n/a	n/a	In the second study, 20% (171) of customers were randomly selected for survey, but data could be obtained from only 122 members of this group. In the first study, all customers were selected by matching the SCE list of interruptible-service customers with the statewide BUGs inventory (Little 2001).
Customers with BUGs in Survey	**44**	n/a	**15**	**12.3%**	**59**	100.0%	Determined through phone survey
Customers owning BUGs that used them on May 8	**10**	22.7%	**5.0**	33.3%	**15**	**25.4%**	There is some rough agreement between the two approaches relative to the fraction of BUGs that were operated. The first survey included results from a considerably larger number of facilities, and thus may be more reliable. For analysis purposes, both data sets were used.
Number of BUGs at facilities using their BUGs	**31**	n/a	**8**	n/a	**39**	n/a	Determined through phone survey
Number of BUGs used per facility	**3.1**	n/a	**1.6**	n/a	**2.6**	n/a	For analysis purposes, both data sets were used to develop an average number of BUGs per facility.
Number of Facilities in SCE area likely using BUGs on May 8	**107**						Extrapolation = 3410 x .123 x .254

Note: "n/a" means not appropriate or necessary to the discussion. Bold numbers are those values used to calculate the results.

The average size of a BUG within the interruptible-service customer group appears to be significantly larger than the average BUG within the "firm" customer group. Based on the responses received, the average size BUG within the interruptible-service group is 998kW. Appendix E contains further details on this data. Also based on the surveys, average usage on May 8, 2001 was 5.1 hours at an average operating load of 95%, for an effective size of 948 kW. Referring to Table 1-7 for the number of BUGs used, non-firm customers produced 1344 MWh of power on May 8. According to data supplied by the Cal-ISO and shown in Table 1-1, 5725

MWh of power curtailments were ordered from SCE non-firm customers. While the Cal-ISO required load reduction for firm customers was limited to a two-hour period, the required load reductions for non-firm customers was spread over a seven-hour period. Thus, the total number of MWh of power generated by non-firm customers' BUGs is assumed to have occurred during the required outage period. On that basis, BUGs appear to have made up 23.4% of the required load reduction for the non-firm sector.

Table 1-7. Estimated BUGs operations for May 8, 2001 power curtailment for SCE interruptible-service customers

Indicator	Number	Comment
Number of BUGs likely to have operated on May 8, 2001	278	Extrapolation = 107 x 2.6
Electricity Generated (MWh)	1344	Calculation = 278 x .948 x 5.1
SCE Load Reduction Required by Cal-ISO (MWh)	5725	From Cal-ISO historical record
Percent of Required Load Reduction Attributable to Operation of BUGs	23.4%	Calculation = 1344/5725
Average Effective Size of BUGs Operated on May 8, 2001 (kW)	948	Determined through phone survey
Average Duration of BUGs Operation on May 8, 2001 (hours)	5.1	Determined through phone survey

1.6. Extrapolation of BUGs Use Estimates to Non-Firm Customers in Other Utility Areas

The same approach used for extrapolations to firm customers was used for non-firm customers. In Section 1.5 it was estimated that 23.4% of the required power reductions were made up by the use of BUGs. This same fraction was extrapolated to non-firm customers in utility districts outside of the SCE area. Table 1-8 shows the results of these extrapolations.

Table 1-8. Estimate of BUGs power generation in various utility region from interruptible customers on May 8, 2001

Utility Region	Power Curtailment (MWh)	Estimated BUGs Generation (MWh)	Estimated Total Number of BUGs Operated on May 8, 2001
Pacific Gas and Electric	420	98.3	20
Southern California Edison	5725	1339.7	277
San Diego Gas and Electric	21	4.9	1
California Department of Water Resources	0	0.0	0
Pasadena	0	0.0	0
Vernon	0	0.0	0
Total MWh	6166	1443	298
Actual Total Fraction of Statewide Demand Reduction Attributable to Operation of BUGs: 23.4%			

1.7. Overall Power Curtailments for May 8, 2001 Power Outage and Resulting Air Pollution

Table 1.9 provides a summary of BUGs operations during the May 8, 2001 power curtailment.

Table 1-9: Summary of BUGs operation on May 8, 2001

Utility Region	Firm Customers (MWh) Adjusted to Two-hour Outage Period	Non-Firm Customers (MWh)	Total (MWh)	Total Requested Curtailment (MWh)	Fraction of Reduction Provided by BUGs
Pacific Gas and Electric	46.5	98.3	144.8	816.8	17.7%
Southern California Edison	39.4	1339.7	1379.3	6061	22.8%
San Diego Gas and Electric	6.9	4.9	11.9	80.2	14.8%
California Department of Water Resources	0.0	0.0	0.0	1200	0.0%
Pasadena	0.4	0.0	0.4	3.2	11.7%
Vernon	0.6	0.0	0.6	4.8	11.7%
Total	**93.8**	**1443**	**1536.9**	**8166.0**	**18.8%**

Tables 1.10 a and b present an overall emissions estimate derived from emission measurements of five diesel-fueled BUGs and the surveyed activity rates. The derivation of the emission factors used in this study is discussed in Appendix A.

Table 1-10a. Summary of BUG emissions on May 8, 2001

Pollutants (tons)	Pacific Gas & Electric (Firm Customers)	Pacific Gas & Electric (Non-Firm Customers)	Southern California Edison (Firm Customers)	Southern California Edison (Non-Firm Customers)
NO_X	1.04	0.87	0.88	11.87
SO_2	0.02	0.02	0.02	0.26
PM_{10}	0.03	0.02	0.02	0.31
CO_2	86.4	73.0	71.4	995.02
CO	0.18	0.15	0.15	2.04
VOC	0.01	0.004	0.004	0.05

Table 1-10b. Summary of BUG emissions on May 8, 2001

Pollutants	San Diego Gas and Electric (Firm Customers)	San Diego Gas and Electric (Non-Firm Customers)	Pasadena	Vernon	Total
NO_X (tons)	0.16	0.04	0.00	0.01	14.7
SO_2 (tons)	0.003	0.001	0.00	0.00	0.3
PM_{10} (tons)	0.00	0.001	0.00	0.00	0.4
CO_2 (tons)	12.6	3.65	0.3	0.4	1225.8
CO (tons)	0.03	0.01	0.00	0.00	2.5
VOC (tons)	0.001	0.000	0.00	0.00	0.1

1.8. Analysis Summary

The investigation included both interruptible-service and non-interruptible-service customers. BUGs-owned/operated by customers on interruptible-service contracts were found to be over 50% larger in effective size as those owned/operated by non-interruptible-service customers. As a result of this effort, it is estimated that a total of 374 BUGs were operated on May 8, 2001 as a direct result of the demand reduction mandated by Cal-ISO. These 374 BUGs generated an overall total of 1537 MWh of electricity and, during the outage period, accommodated 18.8% of the required demand reduction. Using emission factors derived from CE-CERT's BUGs emission testing program, estimates of the criteria pollutant emissions from the operation of BUGs on May 8, 2001 are reflected in Table 1-11.

Table 1-11. Overall results extracted from the analysis

	Non-Interruptible-Service Customers	Interruptible-Service Customers	Total
Number of BUGs operated	76	298	374
MWh Generated	228	1443.1	1671.1
NO_X (tons)	2.09	12.79	14.88
SO_2 (tons)	0.05	0.29	0.34
PM_{10} (tons)	0.05	0.33	0.38
CO_2 (tons)	174	1072	1246
CO (tons)	0.36	2.20	2.56
VOC (tons)	0.01	0.06	0.07

1.9. Determination of Spatial Locations of BUGs Operated on May 8, 2001

Since one of the purposes of this study is to provide input data for ambient air quality modeling, it was also valuable to provide spatial coordinates for each of the BUGs determined to have operated during the May 8, 2001 outage. For those contained in the California Energy Commission's BUGs inventory, the coordinates were taken directly from the inventory. For those contained in the SCE interruptible-service customer list, the addresses were first cross-matched with the statewide inventory. For those that were successfully cross-matched, the coordinates were taken directly from the inventory. For those that did not cross-match, the addresses of the non-firm customers were used with a software-mapping tool to estimate BUGs locations.

Because the number of BUGs established through extrapolation versus confirmed census is a significant portion of the total, it was important that careful attention be given to the calculations. For the extrapolated BUGs, two approaches were employed. For SCE, a list was made of the number of BUGs located in each of the 77 incorporated areas contained within the outage maps. The numbers of BUGs already accounted for as either operating or not operating on May 8 were deducted from the list. Each area was then ranked based on the number of remaining BUGs it contained. The extrapolated BUGs were apportioned within these areas based on the area's ranking. The locations of actual BUGs within those areas were used to establish coordinates for the extrapolated BUGs.

As discussed earlier, a subset of SCE's list of interruptible-service (non-firm) customers was used to identify additional BUGs through both confirmed census and extrapolation. In order to establish locations for extrapolated BUGs, SCE's list of interruptible-service customers was ranked by the number of customers in each incorporated area contained in the list. The BUGs established through extrapolation were then apportioned within these areas at the locations of existing customers. In some cases, BUGs that were identified through this approach were not listed in the statewide inventory. The addresses of these facilities were used in this case along with a software tool for estimating BUG locations.

For PG&E, the statewide inventory was used to establish the number of BUGs within each county in their service area. Because PG&E often encompasses only a portion of a county along the southern and eastern edges of its service area, an effort was made to only include BUGs located within the proper portion of these counties. The counties were then ranked in order of the number of BUGs identified and the extrapolated BUGs were apportioned within these areas based on the ranking. The coordinates for actual BUGs within the statewide inventory were used to establish coordinates for the extrapolated BUGs.

For SDG&E, the ranking of BUGs listed in the statewide inventory was made by both incorporated areas within San Diego county and by zip codes within each incorporated area. This ranking was then used to apportion the calculated number of BUGs within the SDG&E service territory. The coordinates for actual BUGs within the statewide inventory were used to establish coordinates for these extrapolated BUGs.

The results of this analysis are contained in Appendix B, Spatial Coordinates of BUGs Operated on May 8, 2001.

2.0 Policy and Regulatory Issues Report[4]

2.1. Introduction

This report addresses three fairly specific questions:

1. What federal, state, and local air regulations affect the use of backup generators (BUGs) and other forms of distributed generation (DG) in California?
2. What local districts have rules that govern the construction and or operation of BUGs and other forms of DG?
3. What are the timelines and steps associated with meeting the various requirements?

This report responds to these questions with a review of the regulatory framework that governs air pollution control in California, including discussions of the important permitting role played by local air districts relative to the gubernatorial and presidential executive orders (EOs) that might be used to initiate increased usage of BUGs in response to electricity shortages in California. At issue is the likelihood that increases in polluting emissions from even a temporary reliance on BUGs to supplement or offset centrally generated electricity will lead to widespread violations of state and federal clean air laws, and be disastrous to the public's health, particularly in urban areas, which may already be hard-pressed to meet existing air quality standards. This report addresses this critical contingency within the context of more general and widespread efforts in California to craft policy to govern the introduction of DG without further compromising the state's air quality. Additional information on the rules and regulations associated with dispatching BUGs is contained in Appendix I.

2.2. Overview of State Regulatory Framework

Air pollution is regulated at three levels of government in the United States: federal, state, and local. Overall authority is housed at the federal level through chapter 85 of United States Code 42, sections 7401 et. seq., otherwise known as the federal Clean Air Act (CAA), which was most recently amended in 1990. The CAA charges the U.S. Environmental Protection Agency (EPA) with the development of National Ambient Air Quality Standards (NAAQS) and overall management for the achievement of those standards throughout the United States and its territories. It directs each state to prepare a state implementation plan (SIP). State implementation plans include all those rules and regulations a state has developed to achieve NAAQS throughout the state within deadlines established by the U.S. Congress. The CAA further authorizes the EPA to impose sanctions, such as the reduction of federal highway funds, against states that do not prepare a SIP within the required deadline, or subsequently fail to implement their respective SIPs fully. In addition, if a state fails to adopt and/or implement a SIP, the EPA can either adopt and implement a federal implementation plan (FIP) or implement the approved SIP.

Because air pollution control programs had long been in place at the local level by the time the CAA was adopted, many states have come to rely on the expertise of their local programs to

4. This report was originally submitted to the California Energy Commission in April, 2002.

assist in the preparation and implementation of the overall SIP. Permits to emit airborne pollutants are conventionally issued at the local level by city, county, or multi-county agencies. The permits themselves include information on which pollutants are being emitted, allowable emissions rates, and any efforts, such as emission and/or air quality monitoring, that responsible individuals and corporations will be required to take.

There are 35 local agencies in California: 12 air quality management districts (AQMDs) and 23 air pollution control districts (APCDs). Together with the state agency, the California Air Resources Board (CARB), these AQMDs and APCDs work to achieve the NAAQS in the 15 air basins (see maps below) that make up the state. More specifically, CARB is responsible for adopting and enforcing regulations pertaining to state ambient air quality standards and area designations, emissions from motor vehicles, registration of portable engines and associated equipment, fuels and consumer products, and airborne toxic control measures. The California Air Resources Board also is responsible for monitoring the regulatory activity of California's local air agencies. Like the EPA, CARB provides advice and guidance on power plant permitting and emissions regulations; whereas the state's local agencies—or air districts—are responsible for actually adopting and enforcing rules and regulations for stationary sources.

Figure 2-1. California air districts and county boundaries

Figure 2-2. California air basin and county boundaries

2.3. Regulating BUGs and Other DG

2.3.1. Air Quality Regulation and the 2001 Power Emergency

Since the advent of the current energy shortage in California, the air pollution control community at all levels of government has naturally paid much greater attention to BUGs and other types of fuel-based DG. In a recent letter to the secretary of the California Environmental Protection Agency (CalEPA), the EPA provided the following guidance:

> …We agree with CalEPA's assessment that it is important that emergency generators, which typically have high emissions levels, be used only as a last resort to avert blackouts. Based on California's experience this winter [2000-01], we believe it is reasonable for generators to operate during "emergency" situations that may occur prior to an actual interruption of power to the facility and that the following criteria more accurately describe these "emergency" situations: (1) a Stage III emergency for the State of California must be in effect, as declared by the California Independent Systems Operator (Cal-ISO); and (2) rolling blackouts must be imminent or occurring within the facility's air district. As a general matter, the U.S. EPA believes that the definition of "emergency" outlined above is reasonable for the purpose of averting blackouts in California this summer [2001]. Consistent with our prior guidance and our goal of limiting the air quality impacts associated with the use of emergency generators, we believe "emergency generators" should be limited to those generators that operate during an actual blackout within the facility's air district or upon notice of imminent blackouts within the facility's air district, but in no case longer than six hours during any given day….

CARB likewise provided guidance to the local air districts in its letter of February 21, 2001, which states:

> …Diesel-fueled engines are a significant source of emissions of oxides of nitrogen (NO_X) and diesel particulate matter which is a toxic air contaminant. Diesel engine emissions are orders of magnitude greater than a gas-fired plant in terms of pollution produced per megawatt of electricity generated and their routine use can significantly elevate health risks experienced by nearby residents or workers. Use of these units as a routine replacement for power from the grid is inappropriate.
>
> However, in recognition of the energy crisis, CARB staff believes the use of State registered portable generators for emergency power is appropriate under limited circumstances. In the event of rolling blackouts, such registered portable generators should be allowed to generate emergency power at facilities that are experiencing (or shortly expected to experience) a blackout. The use of Statewide registered equipment for this purpose should be limited to the duration of the blackout at the facility, the time needed to switch on the unit in advance of the blackout, and the time needed to maintain power as operations at the facility are switched back to the grid. Although this guidance is directed specifically at Statewide registered equipment not subject to district rules, we believe that a

similar policy should be applied by districts to back-up diesel engine generators permitted or allowed by district regulations….

Shortly thereafter, on February 26, 2001, the California Air Pollution Control Officers' Association (CAPCOA), representing the 35 air districts as a body, issued a "Working Policy on Energy Solutions" which addresses the use of BUGs as follows:

> **Emergency, Standby, and Auxiliary Power Generators**: Numerous and substantive health studies clearly show that combustion of diesel fuel and other fuel oils releases highly toxic emissions. Combustion of diesel and other fuel oils also releases ozone-forming pollutants at enormously higher rates than alternative, cleaner burning technologies and fuels. For these reasons, local air districts strongly believe that combustion of diesel fuel and other fuel oils should be the last resort for meeting power needs. CAPCOA supports the use of alternative clean-burning fuels and technology. When the use of diesel and/or other fuel oils is necessary, emissions controls should be installed. Power generation by combustion of diesel and other fuel oils without emissions control should only occur when blackouts are occurring. CAPCOA would oppose any solution that relies on unlimited or substantial use of diesel or fuel oil combustion without emissions control.

CAPCOA followed its working policy up with a "Coordinated Position on Emergency Power Generation" that was approved on May 1, 2001. That position, in its entirety is as follows:

> **Background:** California's air pollution control and air quality management districts are charged, first and foremost, with protecting the public from unhealthy exposure to air pollution. The districts accomplish this through local rules and policies which carry out broader state and federal mandates. Within this system, districts regulate stationary sources of air pollution based on the contribution of the source or category of sources to local air pollution problems, and on the potential of the source to increase exposure to toxic air contaminants. Using these criteria, districts have historically held emergency back-up power generators to lesser standards of control because these sources typically operate infrequently and for short periods of time. Also, districts recognize the legitimate public need for back-up power generation of essential public services.
>
> **Energy Crisis:** Recent shortfalls in power production relative to demand has led to an increased reliance on emergency back-up power generators. Where these generators are clean burning engines fired with clean fuels, there is no public health or air quality issue. However, the engines are often older, higher emitting, and fueled with diesel. When operated regularly or for extended periods, they contribute significantly to the formation of ozone, and also release significant amounts of diesel particulate exhaust, which was recently identified as a potential carcinogen by the California Air Resources Board. Extensive use of these engines over the next several years would have significant public health consequences, and could negatively impact the economy as well, by raising pollution levels and triggering additional control requirements for industry.

> **Recommendation:** The California Air Pollution Control Officers Association (CAPCOA) recommends that any person or business that can use clean-burning, alternatively-fueled sources of emergency power, do so. When people or businesses must rely on diesel-fueled engines for emergency back-up power, we recommend using the cleanest engines possible, with the lowest sulfur diesel-fuel available, and diesel particulate filters, if feasible. CAPCOA recognizes a legitimate public need for back-up power generation during times of emergency. To this end, CAPCOA is proposing a coordinated approach to engine use during emergencies. This includes unlimited use of emergency back-up power generation during any actual, involuntary power loss, and 100 hours per year of generator operation to ensure reliability (including maintenance, testing, and other limited scheduled uses).

As the California air quality control community has recognized, with the exception of wind- and solar-based DG and fuel cells, currently available DG technologies all emit higher amounts of air pollution per unit of electricity generated than emitted by modern combined-cycle, central-power generation stations. Diesel-fired BUGs, in particular, emit nitrogen oxides, as well as particulate matter (PM_{10}) and fine particulate ($PM_{2.5}$), which has been identified as a toxic air contaminant (CARB Resolution 98-35). As indicated in Table 2-1, on the basis of electrical energy produced, diesel BUGs are at least six times more polluting than large, modern natural gas-fired power plants. These technologies are designed and usually purchased for limited use during electrical outages at the facility level; yet even if used strictly in this capacity, diesel BUGs have the potential to significantly affect California's ability to meet its SIP requirements and achieve the NAAQS for NO_2, ozone, PM_{10} and $PM_{2.5}$. Local air districts have consequently developed regulatory requirements that directly affect the installation and operation of BUGs. The specific regulations currently adopted by 20 of the local air districts[5] were summarized less than a year ago by CARB. An updated version of that summary, provided in Appendix F of this report, shows 20 (57%) of local air districts have rules that govern the operation of BUGs.

2.3.2. State DG Regulation

In addition to providing guidance to local air districts as discussed above, the state has taken other actions to control DG emissions while attempting to assure electricity supplies. In September 2000, the California Legislature adopted Senate Bill 1298 (SB 1298,Bowen and Peace, Chapter 741, Statutes of 2000). This bill directs CARB to issue guidance to air districts on the permitting or certification of electrical generation technologies, and to adopt a certification

---

5. These districts are: Amador County APCD, Antelope Valley APCD, Bay Area AQMD, Butte County AQMD, El Dorado County APCD, Kern County APCD, Mojave Desert AQMD, Monterey Bay Unified APCD, North Coast AQMD, Northern Sierra AQMD, Sacramento Metro AQMD, San Diego County APCD, San Joaquin Valley APCD, San Luis Obispo County APCD, Santa Barbara County APCD, Shasta County AQMD, South Coast AQMD, Tehama County APCD, Ventura County APCD, and Yolo-Solano AQMD. With few exceptions, which are clarified in Appendix 6 the specific regulations apply to internal combustion (IC) engines larger than 50 brake horsepower (bhp).

program and uniform emission standards for electrical generation technologies that are exempt from air district permitting requirements. SB 1298 further specifies that the guidelines address Best Available Control Technology (BACT) determinations for electrical generation technologies and, by the earliest practical date, define emissions standards equivalent to those determined by the CARB to be BACT for permitted central station power plants in California.

Table 2-1. Comparison of fossil-fuel-based DG and combined-cycle generator stations

Source	NO_X Emissions (lb/MW-hr)	PM_{10} Emissions (lb/MW-hr)
Diesel IC Engine w/particulate trap	23	0.1
Diesel IC Engine	21.8	2
Diesel IC Engine w/particulate trap and SCR	4.7	0.1
Lean Burn IC Engine	3	0.4
Small Gas Turbine	1.1	0.2
Micro-Turbine	1	0.09
Rich Burn IC Engine w/catalyst	0.6	0.4
Combined Cycle Gas Generator	0.06	0.04
Phosphoric Acid Fuel Cell	0.03	0
Solid Oxide Fuel Cell	0.01	0

Source: (Adapted from a presentation by James M. Lents to CAPCOA/Environmental Task Force on January 23, 2002.)

In response to SB 1298, CARB proposed "Guidance for the Permitting of Electrical Generation Technologies" and adopted a DG certification program at its November 15, 2001, Board Hearing. The certification program includes emission standards for DG units that take effect in 2003 and 2007; these standards are reproduced in Tables 2-2a and 2-2b. Electrical generation technologies that are only used when electrical or natural gas service fails or for emergency pumping of water for fire protection or flood relief are exempt from the certification program. CARB plans to address emergency generation technologies through future regulatory review. It should be noted that CARB's emission standards for DG provide credit for the use of combined heat and power (CHP). This creates the nexus for both improving air quality and lowering the demand for limited fossil fuel supplies.

Table 2-2a. January 1, 2003, DG emissions standards (lb/MWh)

Pollutant	DG Unit w/o CHP	DG Unit integrated with CHP
NO_x	0.5	0.7
CO	6.0	6.0
VOC	1.0	1.0
PM	An emission limit corresponding to natural gas with fuel sulfur content of no more than 1 grain/100scf	An emission limit corresponding to natural gas with fuel sulfur content of no more than 1 grain/100scf

Source: Proposed Staff Modifications to the Proposed Regulatory Order – Establish a Distributed Generation Certification Program, CARB.)

Table 2-2b. January 1, 2007, DG emission standards (lb/MWh)

Pollutant	Emission Standard
NO_x	0.07
CO	0.10
VOC	0.02
PM	An emission limit corresponding to natural gas with fuel sulfur content of no more than 1 grain/100scf

Source: Same as Table 2a.

It is interesting to note that eight (20%) of California's local air districts have already adopted regulations covering DG defined as stationary sources of electrical power that are smaller than 300 kW and intended to run on a regular basis.[6] Table 2-3 summarizes these district rules. Because the districts that do have DG regulations in place developed them either prior to, or simultaneously with, CARB's DG initiative, it is not surprising that the existing DG regulatory regime is not yet consistent with the new DG certification program. On the basis of our latest review of relevant district regulatory activity (see BUGs and DG regulatory summaries compiled under the auspices of this project), we expect the state's air districts to introduce, within the next 12 to 18 months, more stringent rules to govern the use of DG.

6. These districts are: Bay Area AQMD, Mojave Desert AQMD, San Diego County APCD, San Luis Obispo County APCD, Santa Barbara County APCD, South Coast AQMD, Yolo-Solano AQMD, and Kings County APCD. See Table 4 in the Appendix 6 for details.

Table 2-3. Current district regulation of DG

AQ District	DG Definition	Rule Number	Regulation	Age of Regulation	Compliance with CARB	How Implemented
San Joaquin Valley APCD	IC larger than 50 bhp GT 300kW Solid Fuel Boiler: All	4701 IC (District) 4352 SF 4703 GT	IC: NO_X 640 ppmv RB 740 ppmv LB 700 ppmv diesel CO 2000 ppmv all Boiler NO_X 200 ppmv at 12% CO_2 GT 200 ppmv CO_2	Unknown	No	4352- Tested over a 24-hour average period
SCAQMD	Same but boiler over 5mil Btu	IC 1110.1 GT: 1134 Boiler: 1146.2	Boiler NO_X 30 ppm GT: 25 ppm IC: 90 ppm	1995	No	IC tested for 15 minutes Others unknown
Yolo-Solano	Same as SCAQMD, but all portable diesel added category	IC 2.32 Portable 3.3 Section 303 Boilers 2-27 GT: 2-34	IC : Same as SCAQMD for NO_X and CO Portable NO_X 700 ppmv Boilers same as SCAQMD 42 ppmv GT 42 ppm NO_X	1994	No	Unknown
San Luis Obispo	Same as SCAQMD for IC and boiler	IC:431 Boiler: 430	IC: 50 or 125 ppm NO_X 4500 ppm CO NH3 20 ppmv Boiler: 30 ppmv NO_X 4000 ppmv co	Unknown	NO	Unknown
Santa Barbara APCD		IC: 333				
Continued next page						

IC=internal combustion engines, GT=gas turbines, LB=lean burn, RB= rich burn, ppmv=parts per million by volume.

Table 2-3 (cont.)

AQ District	DG Definition	Rule Number	Regulation	Age of Regulation	Compliance with CARB	How Implemented
Mojave AQMD	Unknown	222	No reporting required if under 5 tons of pollutants a year	1995	No	Unknown
Kings County APCD	Larger than 50 bhp	427	Check if over 50 bhp and if over 250 bhp 80 for Rich Burn;125 for lean; 600 diesel. All for NO_X	2001	No	Unknown
Bay Area AQMD	Less then .3MW	Rag 9 Rule 8	GT: No Regulation RB: 56 LB:140 CO: 2000	1993	No	Unknown

BHP=Brake Horse Power, IC=internal combustion engines, GT=gas turbines, LB=lean burn, RB= rich burn, ppmv=parts per million by volume.

2.3.3. Emergency Measures

Considering that regulation of BUGs in California has evolved in the context of the energy shortage in the state, it is important to mention the authority to regulate air quality granted to the governor, and to the U.S. president, during emergencies. Although the statutory authority of these chief executives is limited, both have the capacity to exercise sweeping power in times of crisis, which many would argue includes the situation in California.

California's governor may use the role of commander-in-chief of the National Guard and the Chief of State associated with the governor's role to augment the power of that office to issue executive orders (EOs), which are entirely independent of the Legislature, and that rescind, modify, or suspend *state* laws and regulations (California Emergency Services Act, CAL. GOV. CODE § 8550 et seq.; see also Lawrence 1999). Governor Gray Davis's recent use of the EO to lift emission limits on some heavily polluting power plants provides a typical and pertinent example (Moraine 2001). Additionally, there are conditions under which the governor may issue EOs that affect *federal* laws, such as the Clean Air Act (CAA).

Governor Davis has issued 50 EOs to date since entering office — 33 since proclaiming a State of Emergency due to the energy shortage on January 17, 2001. These EOs are summarized in Appendix G. Fourteen (42%) of the EOs issued by Governor Davis directly involve local, state and federal environmental and public utilities laws (EOs D-20-01, D-21-01, D-22-01, D-23-01, D-24-01, D-25-01, D-26-01, D-28-01, D-34-01, D-36-01, D-39-01, D-40-01, D-42-01, and D-44-01). To the extent that these measures do not increase the supply of electricity in the state sufficiently to meet rising demand, any one of these EOs might be considered relevant to the use of BUGs to offset residual electricity needs. Six additional EOs (D-4-99, D-16-99, D-17, 99, D-

18-99, D-19-99, D-38-01) might very indirectly impact the use of BUGs in California (see Appendix G).

The EOs primarily affect state environmental and public utilities laws and regulations. Yet provisions under EOs D-24-01, D-28-01, D-34-01, and D-40-01 point to potential conflicts with federal law. Attorney Peter Greenwald opines that the primacy of federal law would limit the governor's authority, even during a state of emergency (Appendix H). Specifically, the governor may alter federal law only so long as due consideration is given federal regulatory priorities. The meaning of "due consideration" is unclear, and no state or federal case discusses this clause or the relationship between the Emergency Act and federal law. Furthermore, there is no CAA provision authorizing the governor to suspend or modify SIPs on a statewide basis. The governor is, however, permitted to suspend California's SIP as it pertains to individual polluting sources, as described in the CAA. In particular, according to section 110(f) of the CAA, one of the two following procedures must be completed in order to modify, suspend, or rescind such requirements in the SIP due to an energy emergency:

1. The state must adopt and obtain EPA approval of a SIP revision after providing for public notice and comment, or
2. The governor must issue a temporary emergency suspension after—
   A. the President declares that a national or regional energy emergency exists of such severity that a temporary suspension or part of the SIP may be necessary, and other means of responding to the energy emergency may be inadequate, and
   B. the governor finds that there exists in the vicinity of each source receiving a suspension an energy emergency involving high levels of unemployment or loss of necessary energy supplies for residential dwelling, and such unemployment or loss can be totally or partially alleviated by such emergency suspension.

The EOs issued by Governor Davis are not consistent with these provisions. First, California did not obtain EPA approval for a SIP revision. Second, although the federal government did recognize a state of emergency in California, the EO pursuant to the state's energy crisis was declared by the Department of Energy (DOE) as a condition for requiring the sale of available electricity to the California Independent System Operator (ISO) (see order dated 14 December 2000 pursuant to Section 202 (c) of the Federal Power Act). Its legal authority is, therefore, subject to congressional approval except in the most urgent cases (Harris and Milks 1996; Jana et al. 1990; Sideman 1998). Considering that this DOE order expired more than a month before Governor Davis issued the first EO contradictory to the federal CAA, it could not fulfill requirement 2A above.

Even if it were reasonable to argue that the governor did conform with the procedures required by section 110(f) of the CAA to modify, suspend, or rescind requirements in California's SIP in this case, he certainly violated the federal CAA requirements that limits emergency changes in SIPs to temporary measures applicable only to individual sources of pollution. According to Greenwald, a court would most likely support an interpretation of section 110(f) that:

> requires a case-by-case determination, including findings of fact explicitly referencing and related to each source subject to an emergency suspension. This interpretation would preclude the issuance of a blanket suspension applicable to all sources in a category (see Appendix H).

In sharp contrast to a governor's limited authority to rescind, modify, or suspend *federal* laws and regulations, even in an emergency, the office of the U.S. president has over time established a clear precedent for the exercise of implied executive power over environmental policy. Article II, Section 1 of the Constitution grants the president "executive powers," but fails to define the range and scope of these powers. Article II, Section 3 charges the president to "faithfully execute" the laws. According to Jonathan West and Glen Busman (1999):

> These two elastic phrases have been interpreted to provide the basis for discretionary power that the president can exercise as chief executive beyond that which is expressly specified….It enables the president to issue directives with the force of law, but does not require advance congressional approval.

Up to just over a third of all EOs issued during and since the Franklin Roosevelt administration have been used to affect environmental regulations. Moreover, EOs and proclamations have been used frequently since that time as policy-making tools as well as administrative mechanisms. On average, 71% of all environmental EOs have been used to implement congressional statutes; 24% of environmental EOs have been used to establish executive agencies (e.g., the EPA) or to reorganize the federal bureaucracy; and 5% of these EOs were issued as the basis for new environmental initiatives (i.e., to make law). This executive policy-making behavior has increased significantly since the Richard Nixon administration. The George W. Bush administration has, to date, issued 52 EOs. Three of these, or less than 6% (131211, 13212, 13222), address energy or energy-related concerns. Only one—#13212, "Actions to Expedite Energy-Related Projects"—bears even indirectly on the use of BUGs in California.[7]

7. By way of providing some indication of federal attention to the state's energy situation, President Bill Clinton issued 53 EOs during his final year in office; none of them had any bearing on the developing energy crisis in California.

2.4. The Public and Environmental Activism

California is widely recognized as an environmental leader — both with respect to its prescient institution of relatively strict air quality regulations, and in connection to its citizens' generally high level of awareness about air pollution and energy conservation issues. This situation should not be surprising given the "unusually influential" role of organized interest groups in state and local politics in California (Field and Sooner 1999, 30). In fact, California ranks first among the top 10 "contributor states," according to the Federal Election Commission (see Lawrence 1999, 108). The roles that are being played by professional associations, environmental organizations, and other groups relevant to the areas of air quality and energy use should not be underestimated. We have already discussed at some length the influence of CAPCOA on the development of regulatory policy to govern the use of BUGs. Environmental interest groups, including the National Resources Defense Council and Clean Air Now, and industry groups, such as Energy Alternatives and the California Hydrogen Business Council, have taken their place alongside political parties, foundations, corporations, and individuals among the many actors currently involved in lobbying and otherwise advocating specific positions on DG regulation in the state.

The diverse and pronounced activity of environmental, industry, and other interest groups around the issue of BUGs and other forms of DG—especially the less expensive and more accessible fossil fuel-based varieties of this technology—arguably explains two striking characteristics of the current public reaction to the energy crisis. First, the residents of California responded predictably and intelligently to the threat of electrical blackouts during the summer of 2001. That is, for a number of economic reasons, including higher electricity prices and rebates for conservation, and social or ethical motives, such as utilitarianism and fairness, "voluntary conservation prevented rolling blackouts throughout the state" (Marko and Radisson 2002, 13; see also Richter 2001). The collective activism of interest groups is implicated as a source of the information on which consumers based their conservation decisions. Second, despite the opportunity that now exists for interest groups to change the structure of electricity generation and transmission, and improve air quality in the state, there has been remarkably less activism than we might expect (Field and Sooner 1999; Lawrence 1999; see also Keck and Skink 1998, and Wagner 1996). A series of personal interviews and less formal conversations with experts in DG technologies, environmental activists and regulators, and others concerned about the quality and cost of environmentally beneficial electricity sheds some light on this observation. These discussions suggest that while politicians, energy and air quality agencies, and interest groups have done a wonderful job of educating the public about the state's energy crisis, they have been much less successful in articulating a vision for the future.[8] It is our

8. Foremost among those interviewed are: Michel Brazeau, Engineer, Canadian Environmental Protection Service; Keith Davidson, President, Energy Nexus Group; and Christian Lagier, Western Regional Manager, Northern Power Systems. Others who have been integral to this ongoing discussion include: Gene Anderson, Professor of Anthropology, University of California, Riverside; Peter Babilo, graduate student, California Institute of Technology; Pat Chapman, Owner and Director, Chapman Ranch School; Max Neiman, Professor of Political Science, University of California, Riverside; Scott Silverman, graduate student, University of California, Riverside.

opinion that such a vision is essential to the establishment of a sustainable energy-air quality regime for California.

2.5. State Regulations as Modeling Constraints

The positions articulated by the air pollution control agencies at each level of government and expressed via EOs by Governor Davis—in addition to existing air quality regulations—can significantly affect efforts to implement least emissions dispatching of electricity generation from BUGs and other forms of DG. Each dispatching scenario developed in conjunction with this project will be scrutinized in relation to the positions, regulations, and policies of the environmental regulatory community and their potential impact on its implementation. To the extent that it is reasonable and feasible, we will also consider the possibility that environmental groups could act to "tie up" specific regulatory changes, particularly those initiated by EOs, in the courts. Such environmental activism could play an important role in the evolving use of BUGs and other forms of DG.

3.0 Atmospheric Modeling

3.1. Atmospheric Modeling Summary[9]

The air quality and health effects analysis is being carried out in a two-step process. In early 2001 it was anticipated that large-scale power shortages and use of BUGs would occur during summer 2001. This created an urgent need for an estimate of the likely air quality and public health impacts that would result. To meet this need, a preliminary modeling study was carried out during April to July 2001, and the results are described in a progress report submitted by the University of California, Riverside to the Energy Commission in July 2001. Although there were large uncertainties in the population, location and emissions factors for BUGs, the preliminary modeling analysis established that even with conservative estimates for BUGs emissions, there was the potential for substantial harmful effects for both local scale exposure to air toxics and for urban to regional scale production of secondary air pollutants.

For a number of reasons, the expected power shortfall has not occurred, and widespread deployment of BUGs is now less likely. Nonetheless, a refined analysis of air quality and health effects of BUGs is still necessary for the following reasons:

1. Use of BUGs is still likely to occur in the case of emergencies, and large uncertainties remain in emissions rates and health effects of this emergency use.
2. A large population of BUGs was installed during the past two years, and their operation cannot be ruled out.
3. The widespread adoption of BUGs is emblematic of a shift to distributed energy generation systems, and the same modeling tools that are developed and employed here.

Therefore, this document describes our plan to evaluate the air quality and health effects of BUGs. It builds on the preliminary studies that were carried out earlier. It also describes the models and tools used in the assessment of air quality and health effects.

3.1.1. Models and Databases Used in BUGs Assessment

Emissions of NO_x and PM from backup diesel generators can have both local-scale and urban-to regional-scale effects. At the local scale, on the order of 0.1 to 1.0 kilometer (km) from the source, the primary effects are high ambient concentrations of NO_2 and PM and possible human health effects. At the urban to regional scale, on the order of 1 to 100 km from the source, the increased NO_x emissions will enhance production of ozone and secondary PM and will increase the probability of violations of the NAAQS for ozone and PM. These species have a complex response to changes in NO_x emissions—for areas close to the source, NO_x emissions may either inhibit ozone production or accelerate the production of ozone, depending on the ratio of VOC to NO_x in the air. At greater distances downwind from the source region, NO_x emissions will contribute to increased production of ozone and particulate. However, the rate and the magnitude of formation of ozone and PM depend on the meteorological conditions and the concentrations and the ratio of VOC/NO_x. The meteorology and photochemical reactions that

9. This report was originally submitted to the California Energy Commission in November 2001.

control ozone and PM formation are highly non-linear. For example, a single molecule of NO_x can catalyze the production of between 2 to 40 molecules of ozone, depending on the ambient conditions. As a result, the possible effects of new NO_x emissions sources on attainment of the ozone and PM NAAQS must be modeled using physically comprehensive, three-dimensional air quality models. A complete description of the complexity of photochemical air pollution is described in Appendix D.

We describe next proposed modeling efforts to assess possible impacts of BUGs emissions on both local-scale health impacts and on attainment of the NAAQS for ozone and fine PM.

3.1.1.1. Local-Scale Dispersion Modeling

Several different dispersion models are available for estimating concentration fields in the vicinity of point sources. The Industrial Source Complex (ISC) models are specially designed to support the EPA's regulatory modeling programs. The ISC can represent a variety of source configurations including the use of stack-tip downwash, buoyancy-induced dispersion, plume rise, and dispersion for calm wind conditions. The ISC can be run in either a short-term or long-term model to predict hourly or annual average concentrations, respectively. The ISC models also incorporate the COMPLEX+1 screening model dispersion algorithms for receptors in complex terrain, i.e., where the receptor elevation is above the release height of the source. The user has the option of specifying only simple terrain (i.e., ISCST) calculations, only complex terrain (i.e., COMPLEX1) calculations, or of using both simple and complex terrain algorithms. The user may select either rural or urban dispersion parameters, depending on the characteristics of the source location. The user also has the option of calculating concentration values or deposition values for a particular run. For the short-term model, the user may select more than one output type (concentration and/or deposition) in a single run, depending on the setting for one of the array storage limits. The user can specify several short-term averages to be calculated in a single run of the ISC Short Term model, as well as requesting the overall period (e.g., annual) averages.

We propose to use the ISC model to estimate ambient concentrations of PM and NO_2 proximate to BUGs emissions sources. Several different dispatch scenarios for the use of BUGs will be considered, and two different terrain configurations will be used: (1) an urban landscape configuration with high surface roughness, and (2) a terrain with no buildings close to the BUG source. We will explore two different approaches to construct estimates of annual average human exposure to BUGs emissions: the short-term hourly average concentrations and the long-term annual average concentrations.

Because BUGs dispatch strategies are expected to be intermittent and may be weighted toward particular seasons or hours of the day, we expect that the short-term version of the ISC will be the most appropriate for estimating ambient PM dispersion from BUGs. We will operate the ISC to determine average concentrations of PM and NO_2 for an aggregation of meteorological conditions that are weighted according to the dispatch strategy. Meteorological fields will be obtained from simulations of the Mesoscale Model Version 5 (MM5) for a range of seasonal and atmospheric stability conditions. The MM5 simulations have already been performed by the EPA for all of California using a coarse 36 km and a nested, fine-resolution 12 km grid for calendar year 1996. We will interpolate meteorological variables for the seasons or conditions that correspond to various BUGs dispatch scenarios and use these to estimate dispersion parameters. Human exposure will be estimated by using geographic information systems (GIS) based population maps in conjunction with the ISC hourly predictions of concentration fields to estimate changes in annual average human exposure to PM and NO_2.

Although we expect that ISC will be the best model to use for PM exposure studies, we will consider other possible dispersion models before beginning the modeling exercise.

3.1.1.2. Airshed Modeling for NAAQS

To predict effects of NO_x emissions on changes in regional-scale ozone and secondary PM, it is necessary to run three-dimensional (3-D) airshed simulation models. The first generation 3-D airshed models were developed and applied in the early 1980s (e.g., the UAM IV). These models were subject to errors, because there were large uncertainties in model inputs and there were inadequate data to perform model performance evaluations. Because of the non-linearly of the photochemical system, these models could be easily "tuned" to fit available ambient data. This tuning process frequently introduced compensating errors into the models' inputs (emissions, chemistry, and meteorology) so that the model gave correct predictions for the wrong reasons. This meant that the model was invalid for predicting future conditions with changes in model inputs.

There has been substantial progress in model development since the 1980s, both in the quality of the science represented in the model and in the amount of data that is available for model performance evaluations. Although uncertainties remain in key model inputs (most notably in the emissions inventories), new generation air quality models can be used to predict the sensitivity of ozone and PM to changes in model inputs with much greater confidence than in the past. In this project we propose to use the EPA's third-generation modeling system, Models-3, which includes the Community Multiscale Air Quality (CMAQ) model. The CMAQ is a state-of-the-science air quality model that offers a range of choices in science algorithms, includes advanced diagnostic outputs and has been applied by several modeling groups. The CMAQ adopts a "one atmosphere" approach, in which a single model is used to simulate all atmospheric processes including gas-phase criteria pollutants, particulates, and air toxics.

In this study we propose to use the CMAQ model with data sets that are being developed by the California Air Resources Board and by California's air districts. These data sets are prepared for air pollution episodes that occurred during several intensive field campaigns, including the 1997 Southern California Ozone Study and the 1990 and the 2000 Central California Ozone Studies. The development of the data sets and the performance evaluation for these model simulations has been a multiyear collaborative research effort that includes staff from the CARB, several California air pollution control districts, and researchers from several University of California campuses. In addition to the ambient data from the field studies, extensive work has been done to improve the quality of model inputs including chemical mechanisms, emissions inventories, and meteorological fields. As a result, high-quality air pollution model scenarios have become available for the first time.

We performed base case model simulations using the data sets for the air pollution episode described above. We then performed model sensitivity simulations in which emissions from BUGs are added to the inventory. We developed new emissions inventories for NO_x, from BUGs based on both AP-42 emissions factors and new emissions factors developed through the testing phase of this project. CE-CERT adapted the Sparse Matrix Operator Kernel (SMOKE) emissions processing system for California and to incorporated the BUGs emissions data into the SMOKE system. The SMOKE system was also augmented to perform emissions processing for various BUGs dispatch scenarios. CE-CERT then evaluated local effects of BUGs on ozone, NO_2, and PM using dispersion models and evaluated urban to regional scale effects on ozone, PM and visibility by applying one or more of the grid models listed above.

Because it required over a year to develop new emissions inventories for BUGs based on the testing, and because of the urgency of this project, we performed several mode-sensitivity simulations in an early phase of the project in which we approximated BUGs sources and evaluated effects on model-predicted ozone and PM. This activity served as a "first-cut" screening process to evaluate the likely air quality effects of widespread use of BUGs for emergency power generation. Additional, more refined emissions inventories and model simulations were then performed later in the project, after the new BUGs emissions testing results became available.

3.1.2. Modeling Plan

There are a wide variety of regulations and air quality standards that may affect the use of DG and, in particular, the use of backup diesel generators. There exist both state and federal air quality standards for ozone, nitrogen dioxide, fine particulates, and air toxics. Moreover, for certain pollutants there exist multiple standards that may be applicable, and the effects of DG on attainment of each of these standards may vary as a function of temporal and spatial sales. For example, ozone is subject to a California standard of 90 ppb calculated as a 1-hour average, a federal standard of 120 ppb calculated as a 1-hour average, and a federal standard of 80 ppb calculated as an 8-hour average. Particulates are also subject to multiple regulations. Primary and secondary particulates from diesel engines are variously regulated as air toxics, as fine particulates, as coarse particulates, and in relation to their effects on regional haze. To evaluate the possible effects of DG on the various air quality standards, it is necessary to make use of a variety of modeling approaches that encompass the large range of relevant spatial and temporal scales.

In the July 2001 report, we presented <u>preliminary</u> findings on:

- The emissions inventories used for modeling.
- The parameters that affect BUGs emissions for the case of an ideal, uniform wind field.
- The impacts of NO_x emissions on formation or inhibition of ozone and formation of secondary particulate matter.
- Uncertainties in chemical kinetics and model scenarios.
- Effects of BUGs operations on ozone formation in Central California using the SARMAP Air Quality Model with a 5-km grid resolution for a three-day air pollution episode in 1990.
- Effects of BUGs operations on ozone, particulate, and visibility using the Models-3 Community Multiscale Air Quality Model with a 36-km grid resolution for July, 1996.

The additional tasks to be carried out fall under three broad categories:

1. Application of enhanced tools for presenting results of modeling studies to managers and policy makers.
2. Development of improved modeling tools and base case scenarios for evaluating BUGs impacts.
3. Carrying out new model simulations using updated BUGs emissions inventories

Each of these are described below.

3.1.2.1. Application of enhanced presentation tools

One of the difficulties inherent in modeling studies is the communication of model simulation results by scientists to managers and policy makers. For example, the results of the dispersion modeling that we presented in our preliminary report provided an accurate description of the results of the modeling studies, but the format was such that they may not be readily accessible to non-scientists. One of our goals in this activity is to implement new graphics packages and GIS tools that will help to convey results of model simulations more effectively. Moreover, the implementation of GIS tools will also greatly enhance our ability to perform analyses using data sets that are publicly available. One important application of this software will be to facilitate the estimates of population exposure to emissions from a particular BUG source.

To achieve this capacity, we have acquired software packages, including ARCVIEW, ARCINFO, and SURFER. Project staff are currently applying these tools to develop improved presentation of the dispersion modeling results. Project staff also are currently acquiring training in the use of ARCINFO for compiling population exposure statistics. Training costs for these activities are being covered internally by UCR.

3.1.2.2. Development of more accurate baseline scenarios

One of the key problems in any modeling study is the uncertainty in the model inputs, including meteorology, emissions inventories, and chemical mechanisms. Moreover, extensive evaluation of model results, including comparison to ambient data, is necessary to validate the usefulness of models for predicting the response to changes in emissions.

For the dispersion modeling, we acquired additional meteorological data and compiled a library of data that can be used to estimate dispersion of BUGs emissions and consequent population exposure in several specific locations throughout California. These data were used to perform addition dispersion modeling and health effects assessment after we received the new BUGs emissions factors following the emissions measurements.

The preliminary airshed modeling study that was completed in July 2001 made use of two airshed model scenarios: (1) the SARMAP Air Quality Model (SAQM) that was developed for an O_3 episode in central California for 1990, and (2) an application of EPA's Community Multiscale Air Quality model (CMAQ) for a western U.S. domain for July 1996.

We are continuing to evaluate and revise these base case model scenarios, and to evaluate new model scenarios that can be used for assessing the effects of BUGs or other distributed emissions sources in California. In particular, we have significantly revised the emissions inventory that was used in our previous base case scenario for the CMAQ model. This revision may affect the BUGs analysis in addition to any effects from the revised BUGs emissions scenarios. We also evaluated a base case model in southern California for an O_3 episode that occurred in August 1997. While the support for these efforts to develop improved model scenarios is being provided by other funding agencies, under the funding from the California Energy Commission for the BUGs analysis, we adapted these model scenarios to perform additional analysis relevant to the evaluation of distributed emissions sources in California. These efforts included: additional model evaluation, analysis of population exposure statistics, and development of BUGs emissions scenarios.

3.1.2.3. Final model sensitivity runs using new BUGs emissions data

Based on the results of new emissions data and BUGs population data, we perform a final set of model simulations.

To estimate local scale effects we used the enhanced meteorological data and GIS analysis tools to perform addition dispersion modeling and health effects assessments.

Airshed modeling was performed using the CMAQ model for the western U.S., and using the CMAQ and CAMx models for southern California. We also peformed new model simulations for a central California model scenario developed for the 2000 Central California Ozone Study.

3.2. Atmospheric Modeling: NO_X Emissions and Ozone

Emissions from diesel-powered BUGs are of concern for three reasons:

1. Diesel exhaust is considered a carcinogenic air pollutant by the state of California.
2. In addition to the cancer risks, fine particulate matter ($PM_{2.5}$) in diesel exhaust may contribute to increased, direct mortality (Lloyd and Cackette 2001).
3. Primary emissions of nitrogen oxides (NOx) and carbon monoxide (CO) in diesel exhaust contribute to formation of secondary air pollutants including ozone (O_3), nitric acid (HNO_3), and fine particulate matter ($PM_{2.5}$).

This section describes modeling studies of the effects of BUGs emissions on secondary air pollutants using hypothetical scenarios of 8-hour and 24-hour BUGs operation and also using actual BUGs operation data for a particular power blackout incident. Section 4 discusses health risks from direct emissions of BUGs diesel exhaust.

The air quality and health effects analysis was carried out in a two-step process. In early 2001, it was anticipated that large-scale power shortages and use of BUGs would occur during summer 2001. This created an urgent need for an estimate of the likely air quality and public health impacts that would result. To meet this need, a preliminary modeling study was completed in 2001. The results are described in a progress report submitted by UCR to the California Energy Commission in July 2001. Although there were large uncertainties in the population, location, and emissions factors for BUGs, the preliminary modeling analysis established that even with conservative estimates for BUGs emissions, (i.e., conservative in that the BUGs population was know to be underestimated in the original inventory) there was nonetheless the potential for substantial harmful effects for both local-scale exposure to air toxics and for urban- to regional-scale production of secondary air pollutants. Uncertainties in the 2001 UCR report included incomplete BUGs population data and uncertainty in the emissions factors for PM and NO_X in BUGs exhaust. As described above, more complete BUGs population data have now been compiled, and we also have new emissions factors for PM and NO_X developed from the BUGs emissions testing that was carried out as part of this study. The modeling results reported here include these updated population and emissions data. It should be noted, however, that the emissions data used here are based on test results available in November 2002. The BUGs emissions testing is still in process and final emissions factors will be developed after the testing program is completed. However, it is expected that the new tests will not significantly change the emissions assumptions used in this project to date and that the final emission factors will be similar to the existing emission factors.

In our 2001 report we completed a comprehensive analysis of the variability in ground level exposure to BUGs primary PM emissions. This analysis included: calculation of peak exposure for a range of metrological stability conditions, effective stack heights, and operating parameters for two generic BUGs. This analysis was designed to characterize conditions that might exacerbate or alleviate exposure to PM from BUGs. This analysis is not repeated here. In this report, however, we do perform an analysis of possible health effects from BUGs using meteorological data for two specific sites, and these results are described in Section 4.3 .

3.2.1. Background on Air Quality Modeling for NAAQS

Emissions of NO_X and PM from backup diesel generators can have both local-scale and urban- to regional-scale effects. At the local scale, on the order of 0.1 to 1.0 km from the source, the primary effects are high ambient concentrations of NO_2 and PM and possible human health effects. At the urban to regional scale, on the order of 1 to 100 km from the source, the increased NO_X emissions will enhance production of ozone and secondary $PM_{2.5}$, and will increase the probability of violations of the NAAQS for ozone and PM. These pollutants have a complex response to changes in NO_X emissions – for areas close to the source, NO_X emissions may either inhibit ozone production or accelerate the production of ozone, depending on the ratio of VOC to NO_X in the air. At greater distances downwind from the source region, NO_X emissions will contribute to increased production of ozone and $PM_{2.5}$.

However, the rate and the magnitude of formation of ozone and $PM_{2.5}$ depend on the meteorological conditions and the concentrations and the ratio of VOC/ NO_X. The meteorology and photochemical reactions that control ozone and PM formation are highly non-linear. For example, a single molecule of NO_X can catalyze the production of between 2 to 40 molecules of ozone depending on the ambient conditions. As a result, the possible effects of new NO_X emissions sources on attainment of the ozone and $PM_{2.5}$ NAAQS must be modeled using physically comprehensive, Eulerian (i.e., spatially gridded in three dimensions) air quality models.

The first generation Eulerian airshed models were developed and applied in the early 1980s (e.g., the Urban Airshed Model (UAM)). These models were subject to errors, because there were large uncertainties in science algorithms, errors in model input data sets, and limited computational resources for simulating pollutant formation on high-resolution regional grids. Because of the non-linearity of the photochemical reactions that produce O_3 and $PM_{2.5}$, early models were frequently “tuned” to fit ambient monitoring data. This tuning process frequently introduced compensating errors into the models’ inputs (emissions, chemistry, and meteorology) so that the model gave correct predictions for the wrong reasons. These errors limited the value of early models for predicting the effects of changes in precursor emissions on concentration of O_3. Moreover, these models did not represent the formation of secondary fine particulates.

There has been substantial progress in model development since the 1980s, both in the detail of the science represented in the model and in the amount of data that is available for model performance evaluations. Although uncertainties remain in key model inputs, most notably in the emissions inventories, new generation air quality models can be used to predict the sensitivity of ozone and PM to changes in model inputs with much greater confidence than in the past. We used three different air quality models in this project:

- The SARMAP Air Quality Model (SAQM) (Chang et al. 1997) is a three-dimensional, regional-scale, non-hydrostatic air quality model developed to simulate transport, dry deposition, and chemical transformation of photochemical pollutants. SAQM was developed specifically for air quality modeling for a 1990 field study in central California.
- The Comprehensive Air Quality Model with extensions (CAMx) was developed by ENVIRON Corporation (ENVIRON 2002) for urban and regional scale modeling of O_3.
- The U.S. EPA's third-generation modeling system, Models-3, which includes the Community Multiscale Air Quality (CMAQ) model (Byun 1999) is a state-of-the-science air quality model that offers a range of choices in science algorithms, includes advanced diagnostic outputs, and has been applied by several modeling groups. The CMAQ adopts a "one atmosphere" approach, in which a single model is used to simulate all atmospheric processes, including gas-phase criteria pollutants, particulates, and air toxics.

We applied these models for four different historical air pollution episodes:

- The 1990 SARMAP O_3 field study for Central California using a simulation period from August 3–6, 1990.
- The 2000 Central California Ozone Study (CCOS) study using the CAMx model for a simulation period from July 30 to August 2, 2000.
- The 1997 Southern California Ozone Study (SCOS97) for southern California, using the CMAQ model for a simulation periods
- The 1996 Western Regional Air Partnership study for the western United States, using the CMAQ model for a simulation during July 1996.

In each of these cases, we relied on the available "base case" model input data sets that had been developed under separate funding or by other agencies. The development of model inputs and the model performance evaluation and validation are large-scale, resource-intensive efforts that typically involve multiple institutions and require several years to develop. Therefore, we have leveraged our analysis for the BUGs study by using the available data sets.

For each model and scenario, we repeated the base case model simulations using the previously available emissions and meteorological data sets. We then created a new emissions inventory in which we added the BUGs emissions for a particular BUGs deployment scenario to the base case emissions inventory. We then performed air quality model sensitivity simulations to estimate the effects of BUGs emissions on secondary pollutants, either O_3 or $PM_{2.5}$. We estimated the effects of the BUGs emissions by comparing the results of the simulation of the BUGs deployment scenario to the base case scenario. We typically present the results as "difference plots" showing the change in O_3 or $PM_{2.5}$ compared to the base case scenario.

Our goal in performing these sensitivity studies was to determine whether the BUGs emissions would substantially interfere with the attainment of air quality standards or cause new exceedances of air quality standards. In particular, we focused on the NAAQS for O_3 which is 0.12 parts per million (ppm) or, equivalently, 120 ppb. For typical clean conditions, background concentrations of O_3 are on the order of 30 to 50 ppb. In the historical episodes used in our base case simulations, we observed that peak O_3 levels were typically between 120 to 170 ppb. A change of a few ppb in O_3 in the model simulation is considered significant, because it could cause an area that was marginally in attainment of the NAAQS to become non-attainment. Moreover, because high ambient O_3 levels are caused from the combined emissions from many thousands of individual sources, usually no single source is responsible for an exceedance of the NAAQS, so even small contributions to O_3 formation from a particular source is considered to be significant.

It should be noted that the studies reported here assess the effects of BUGs emissions for historical episodes. These episodes were originally selected because they represented high O_3 conditions that would be useful for developing SIPs for attaining ambient air quality standards. Thus, by adding the BUGs emissions in these scenarios, we evaluated the effects of BUGs for particular, historical air pollution episodes. In the case of the "blackout" episode described below, we modeled what the effect of the BUGs emissions would have been on the historical O_3 episode, rather than the particular meteorological conditions of the blackout scenario day. This is the standard approach that is used in all air pollution sensitivity studies, and this approach is used because of the high cost of developing a new, validated model scenario for a particular day. Thus, we make the assumption that the effects of BUGs emissions would be similar on any high pollution day.

3.2.2. BUGs Emissions Scenarios

There were four modeling scenarios that were completed as part of this study. These scenarios were as follows:

1. **Base Case:** No backup generators in operation.
2. **8-Hour Use Case:** All backup generators in the California Energy Commission database are operated for eight hours in a day.
3. **24-hour Use Case:** All backup generators in the California Energy Commission database are operated for twenty-four hours in a day.
4. **Actual Case:** In this case, the backup generators were assumed to have been operated as determined by the survey carried forward in this study and described in Section 1 of this report.

It was felt that these four cases provide a reasonable range of scenarios to consider the impact of backup generators during power curtailments.

3.2.3. 1990 SAQM 12-km Ozone Model

The SAQM modeling was based on Damassa et al. (1996), and the domain included the Sacramento and San Joaquin Valleys, the Sierra Nevada mountains and the coastal range, and major cities such as San Francisco, San Jose, Sacramento, Fresno, and Bakersfield. There were 34 x 41 model grid cells in the longitudinal, latitudinal directions, respectively. There were 15 layers in the vertical direction and the top of the modeling domain was 15 km high. A logarithmic vertical grid spacing was used to provide better resolution of the planetary boundary layer. The base case emissions inventories and meteorological fields and the base case model performance evaluation were described in Damassa et al. (1996). We performed sensitivity simulations using BUGs population data and BUGs emissions factors that were available early in 2002. Figure 3-1 shows the NO_X base case emissions inventory in the left panel and the NO_X emissions for BUGs in the right panel. NO_X emissions from BUGs were concentrated in Sacramento County, and there were some grid cells in which the BUGs NO_X emissions were as large as all other NO_X sources combined.

Figures 3-2 and 3-3 show the effect of the NO_X emissions on O_3 concentrations at 23:00 Greenwich Mean Time (GMT), which is equivalent to 4 p.m. local time. This is typically the time of day at which the peak 1-hour average O_3 occurs. We show the results for each of the four days in the episode because there can be day-to-day variability in the effects of BUGs on O_3 caused by variability in the meteorology. In the figures, the blue colors indicate areas close to the BUGs sources for which the BUGs NO_X emissions reduce the O_3 concentration. This reduction in O_3, or NO_X disbenefit is the result of NO reacting with O_3 to produce NO_2, and reaction of NO_2 to destroy OH radicals, thereby inhibiting O_3 formation. The NO_X disbenefit occurs only for conditions of low VOC to NO_X ratios and close to large NO_X sources, and these conditions typically have low O_3 concentrations. As the NO_X emissions are aged and dispersed while being transported downwind from the source, the additional NO_X emissions contribute to enhanced O_3 production, and this is shown in the plots as the yellow and red colors. Because Sacramento had very large NO_X sources, as shown in Figure 3-1, the NO_X disbenefit is largest for Sacramento. There are also large increases in O_3 to the south of Sacramento. There were increases of 10 to 16 ppb O_3 in the 8-hour deployment case, and 17 to 28 ppb O_3 in the 24-hour deployment case. These O_3 increases are very large in comparison to the effects of other individual NO_X sources; however, the NO_X emissions factors were based on AP-42 estimates that were highly uncertain and most probably largely overestimated. Our subsequent modeling studies used NO_X emissions factors based on the BUGs testing, which resulted in lower NO_X emissions factors. Thus, the SAQM 1990 results should be considered an upper estimate.

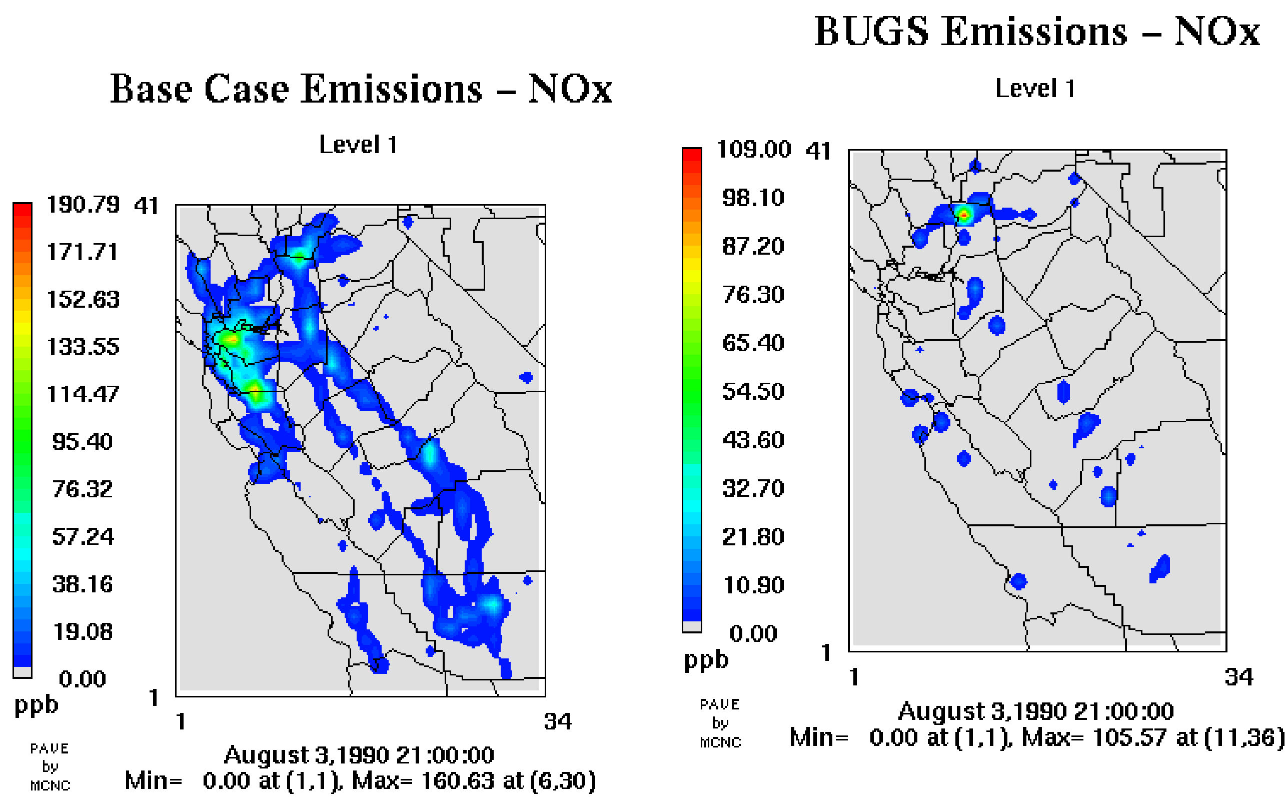


Figure 3-1. Base case NO_X emissions (left) and NO_X emissions from BUGs using incomplete BUG population data for the 1990 SAQM 12-km grid modeling (right)[10]

10. At the beginning of this study, due to the potential of power blackouts, an initial modeling study was carried out before the California Energy Commission BUGs inventory was finalized. Ultimately, analysis reported in this document used the updated BUGs information provided by the Energy Commission and CARB BUGs population studies.

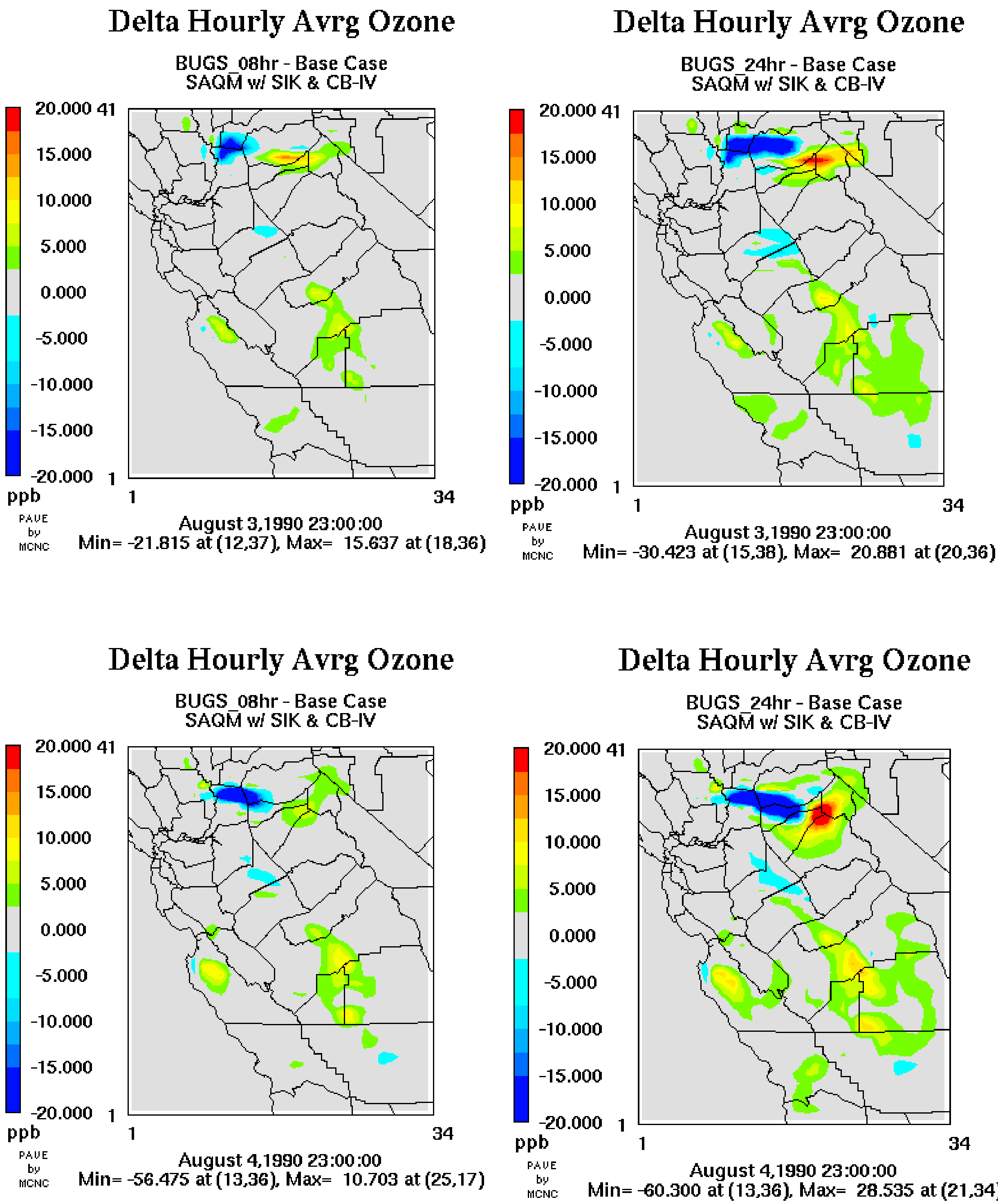


Figure 3-2. Impact of BUGs on O_3 using 1990 SAQM modeling, 8-hour operation (left) and 24-hour BUGs operation (right) for August 3 (top) and August 4 (bottom).

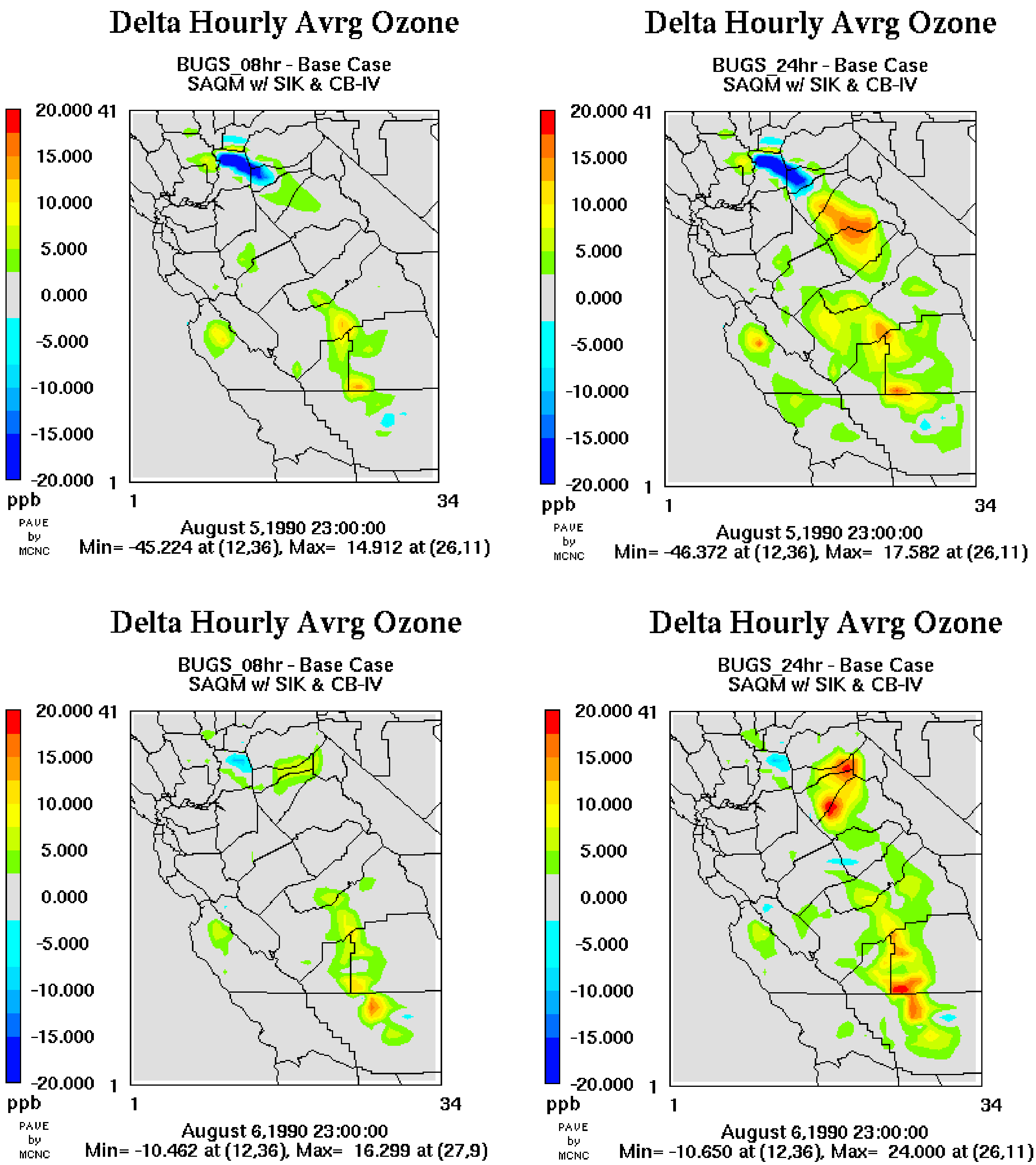


Figure 3-3. Impact of BUGs on O_3 using 1990 SAQM modeling, 8-hour operation (left) and 24-hour BUGs operation (right) for August 5 (top) and August 6 (bottom).

3.2.4. Central California 2000 CCOS Episode

To address concerns with the coarse grid resolution used in the 1990 SARMAP modeling, we also performed sensitivity simulations using data sets that are being developed by CARB and by California's air districts for a 4-km resolution domain for central California. These data sets are being prepared for an air pollution episode that occurred during an intensive field campaign, the 2000 Central California Ozone Study (CCOS). The development of the data sets and the performance evaluation for these model simulations has been a multiyear collaborative research effort that includes staff from the CARB, several California air pollution control districts, and researchers from several University of California (UC) campuses. Although the model scenario for the 2000 CCOS episode has not been finalized, it is useful for a sensitivity study to consider the effects of BUGs NO_X emissions on O_3.

For the 2000 CCOS, modeling the impact of BUGs emissions on O_3 was simulated with ENVIRON's Comprehensive Air Quality Model (CAMx) (ENVIRON 2002). The model scenario used in the simulation was an episode for July 30 to August 2, 2000, which was part of the 2000 CCOS. In the CAMx simulation, we allowed the BUGs to operate for 8 hours (10 a.m.–6 p.m.) and 24 hours to see how different operating schedules affect regional air quality. (Note that this is the same deployment schedule that was used in the SARMAP modeling described above and in the primary toxics dispersion modeling as discussed below, and that these assumptions do not correspond to the actual operating hours experienced in a real outage, as discussed in Section 1.)

Figures 3-4 and 3-5 show the effects of BUGs emissions on O_3 for the CCOS 2000 base case. Results of the CCOS 2000 modeling indicate that BUGs emissions had a smaller effect on the O_3 than did the 1990 SAQM modeling. This is primarily a result of the lower emissions factor for NO_X, although the grid resolution and the scenario conditions may also affect these results. Nonetheless, the CCOS 2000 modeling still shows that BUGs NO_X emissions can have a substantial impact[11] on air quality. In the near vicinity of BUGs sites, the additional NO_X emissions inhibit O_3 productions and reduce the ambient O_3 levels (Figure 3-1). However, the modeling results also show significant increases[12] in O_3 downwind from the BUGs sites. For the 8-hour-per-day deployment schedule, O_3 concentrations close to BUGs sites decreased by more than 10 ppb and increased by 5 to 7 ppb farther downwind. For the 24-hour-per-day deployment schedule, O_3 concentrations close to BUGs sites decreased by more than 15 parts per billion (ppb) and increased by 5 to 10 ppb farther downwind. Spatially the overall pattern of changes in O_3 pattern were similar for the 8-hour and 24-hour scenarios, with the 24-hour scenario showing larger areas of O_3 increase downwind.

Changes of even a few ppb in O_3 are considered to be significant. Clean background O_3 levels are approximately 30 to 40 ppb, and the federal 1-hour average and 8-hour average standards are 120 ppb and 80 ppb, respectively. A change in O_3 of a few ppb represents a significant portion of the O_3 budget and could jeopardize an air quality plan which otherwise showed attainment. Moreover, there are few remaining emissions control categories that can, by

---

11. See Section 3.2.1 of this report "Background on Air Quality Modeling for NAAQS."

12. Ibid.

themselves, achieve a reduction of more than a few ppb of O_3. Thus, these results indicate that the transport of O_3 and 8-hour O_3 standards are likely to be important issues in the operation of BUGs. Note that these results are relevant to short-term episodes of high O_3; a less frequent deployment schedule (i.e., fewer days per year) would not affect these results. However, a shorter operation period (i.e., fewer than the 8 hours per day assumed here) would reduce the impacts on urban and regional O_3.

The effects of BUGs emissions on O_3 production are highly sensitive to the concentrations and ratio of VOC and NO_X into which the BUGs emissions are injected. We hypothesized that the effects of BUGs emissions may change in the future as progress is made toward attainment of the O_3 standard. Therefore, we also performed a hypothetical clean, future base case scenario by reducing anthropogenic VOC and NO_X emissions by 50% across the board. Then, we evaluated the effects of this the 8-hour and 24-hour BUGs deployment schedules using model sensitivity simulation in which we added the BUGs emissions to the hypothetical future "clean base case" scenario. The purpose of the sensitivity scenario was to assess the possible effects of BUGs emissions on peak O_3 levels under a hypothetical future conditions in which and to determine whether BUGs could affect attainment of State or federal Ambient Air Quality Standards. Although the 50% across-the-board reduction in the anthropogenic VOC and NO_X may not be a good approximation of the actual SIP control measures, this sensitivity case may still be useful to asses the variability of the BUGs effects on O_3 as the base case conditions change.

Figures 3-6 and 3-7 show the effects of the BUGs emissions on the "clean base case." Results are similar to the base case results in Figures 3-4 and 3-5. The O_3 increases were slightly smaller in the 8-hour deployment case and slightly larger in the 24-hour deployment case. Table 3-1 compares the maximum increase in O_3 for each of the model scenarios described above.

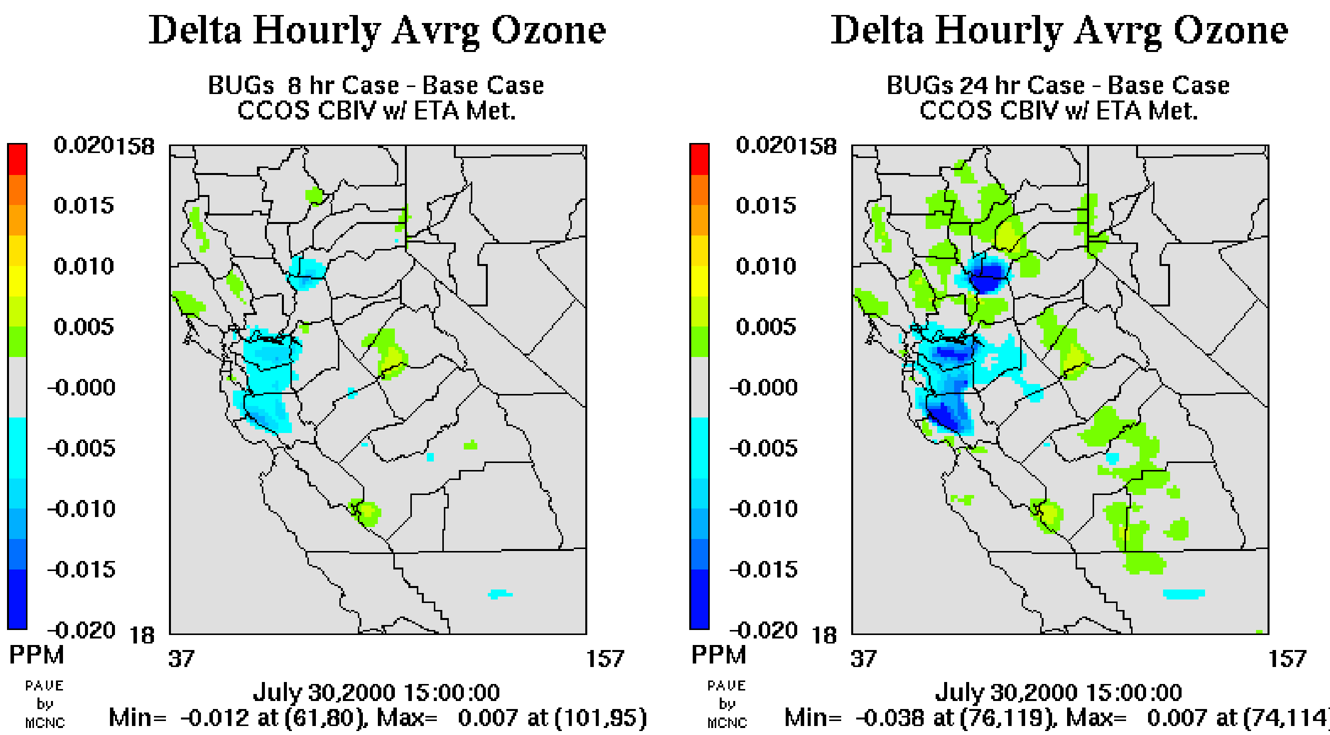


Figure 3-4. Impact of BUGs on O_3 using 2000 CCOS modeling, 8-hour operation (left) and 24-hour BUGs operation (right) for July 30, 2000.

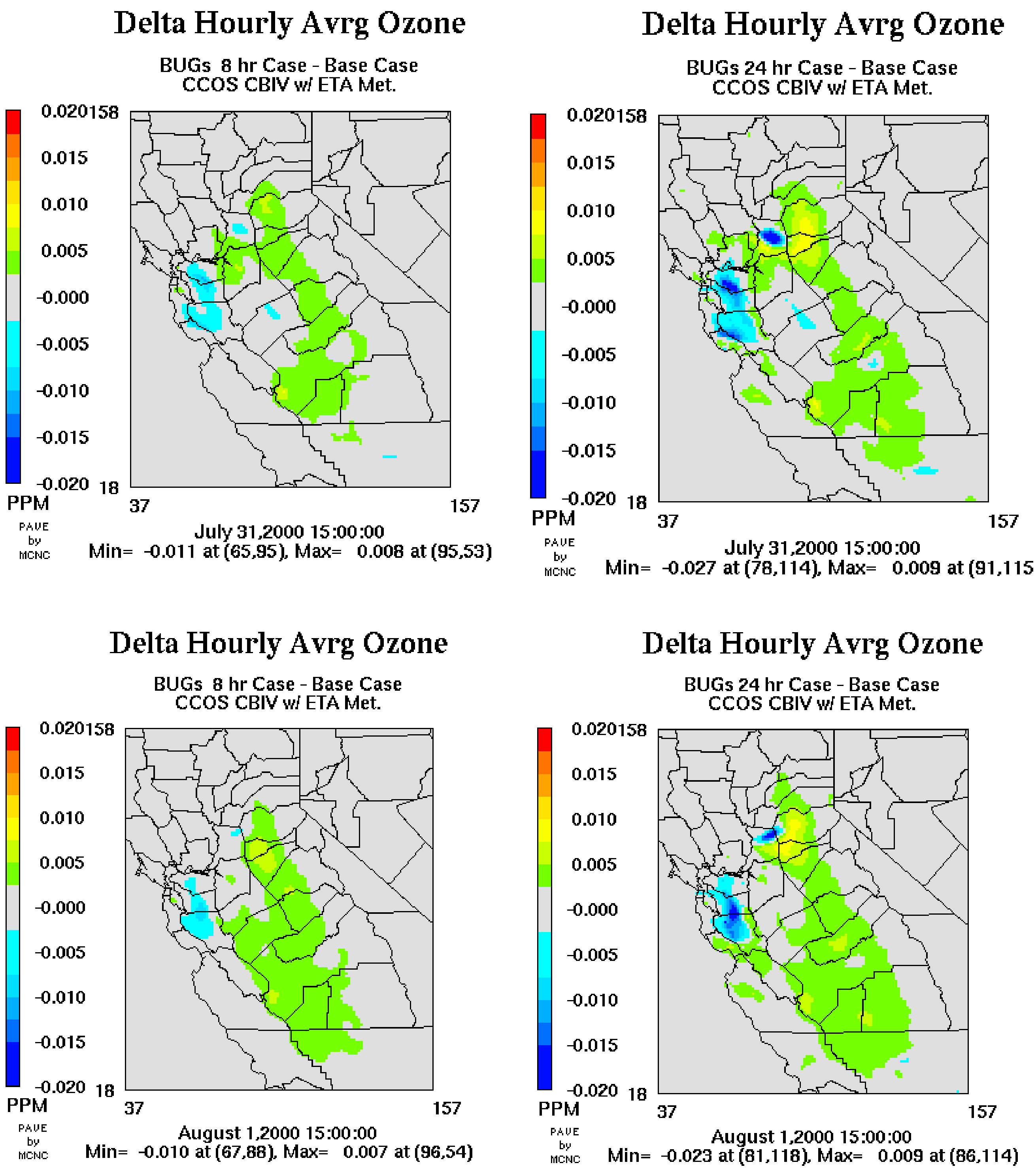


Figure 3-5. Impact of BUGs on O_3 using 2000 CCOS modeling, 8-hour operation (left) and 24-hour BUGs operation (right) for July 31 (top) and August 1 (bottom).

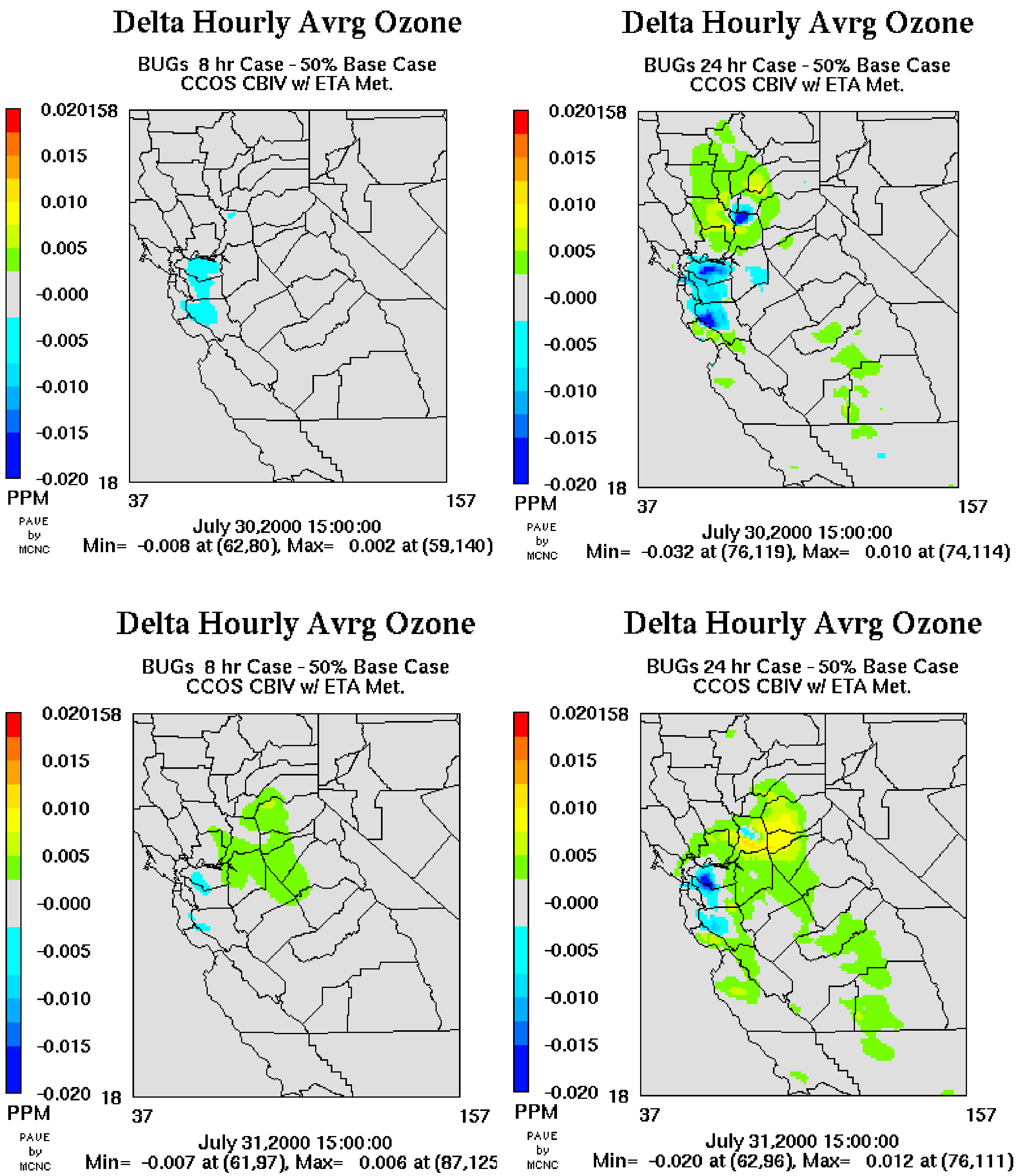


Figure 3-6. Impact of BUGs on O_3 using 2000 CCOS with a 50% reduction in the base case anthropogenic VOC and NO_X emissions, for 8-hour operation (left) and 24-hour BUGs operation (right) for July 30 (top) and July 31 (bottom).

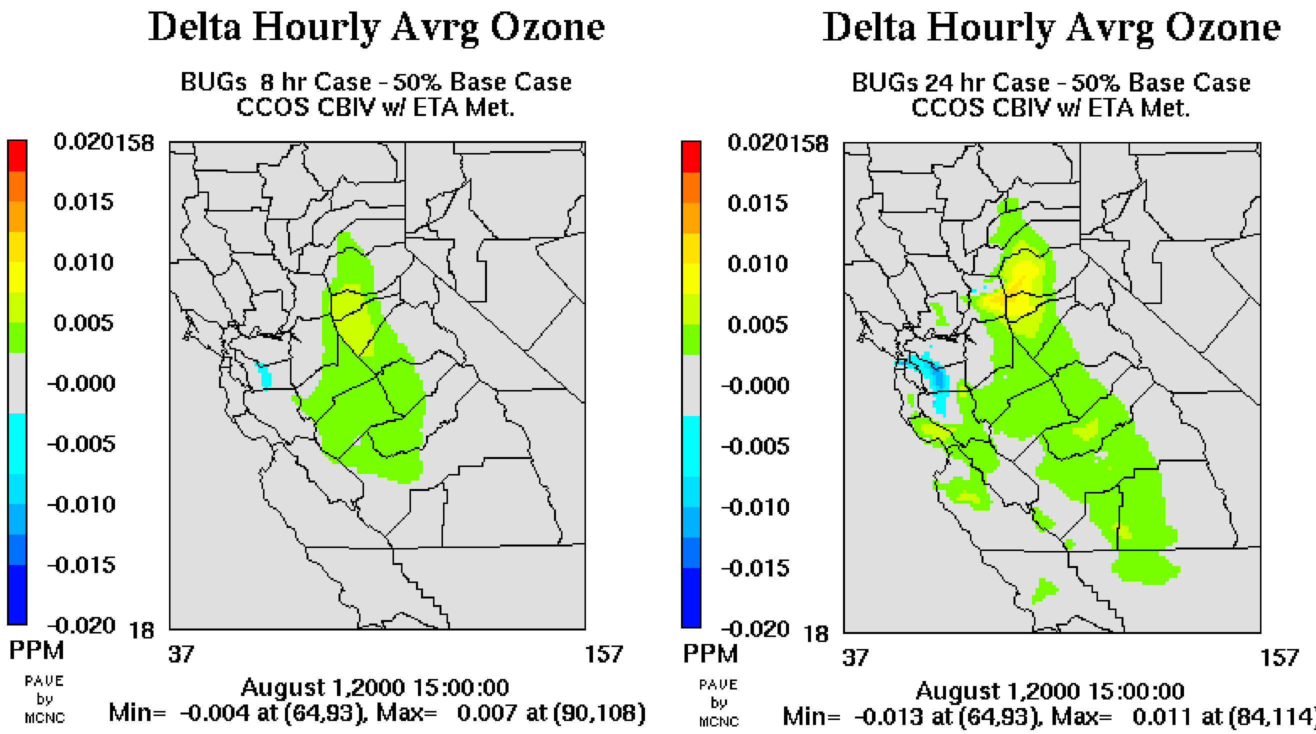


Figure 3-7. Impact of BUGs on O_3 using 2000 CCOS with a 50% reduction in the base case anthropogenic VOC and NO_X emissions, for 8-hour operation (left) and 24-hour BUGs operation (right) for August 1.

Table 3-1. Summary of maximum change in O_3 concentration for the 1990 SAQM and 2000 CCOS BUGs modeling

Case	Date	Max O_3 Increase (ppb)	
		8-hour BUGs Deployment	24-hour BUGs Deployment
SAQM	8/3/1990	16	21
	8/3/1990	11	29
	8/3/1990	15	19
	8/3/1990	16	24
CCOS	7/30/2000	7	7
	7/31/2000	8	9
	8/1/2000	7	9
CCOS 50% Reduction in base VOC&NO_X	7/30/2000	2	10
	7/31/2000	6	12
	8/1/2000	7	11

3.2.5. Coarse Grid Regional Modeling

The Western Regional Air Partnership (WRAP) has implemented a regional planning process to provide the modeling tools needed by states and tribes to comply with the Clean Air Act requirements for visibility and regional haze. As part of this effort, the WRAP is sponsoring modeling studies to support the development of State and Tribal Implementation Plans (SIPs and TIPs) for regional haze. The University of California, Riverside, is performing air quality modeling for the WRAP and has developed model inputs and annual model scenarios for a base case year of 1996.

Although the WRAP domain employs a very coarse resolution grid (36 km), it also presents several advantages in comparison to other model scenarios, which were designed to simulate O_3 episodes of a few days within California's southern or northern regions. The larger WRAP domain and longer simulation period allows for evaluation of the effects of transport of O_3 and its precursors as well as evaluation of regional haze. The WRAP model scenario also includes modeling of $PM_{2.5}$ and thus it can be used to evaluate the effects of BUGs emissions on $PM_{2.5}$. The coarse grid resolution makes the WRAP domain less useful for evaluating peak O_3 impacts in or near urban areas, but it is useful for evaluating regional transport.

We employed preliminary data sets both for the WRAP base case emissions and for the BUGs emissions. We have repeated the BUGs sensitivity scenarios using the final WRAP input data sets and using the revised BUGs emissions factors developed from the BUGs testing program. Figure 3-8 shows the hourly emissions rates used in each 36-km grid cell. Simulations were run for both 8-hour and 24-hour deployment scenarios. Figure 3-9 shows example results for 2 days from the 31-day simulation period. The results are shown as change in O_3 at 4 p.m. PDT for both the 8-hour and 24-hour BUGs deployment schedules for July 15 and 30. The left panels in

Figure 3-9 show the results for the 8-hour BUGs deployment while the right panels show the 24-hour deployment. As expected, there is considerable day-to-day variability in the effects of the BUGs emissions as a result of variability in the meteorological conditions. On most days there is a reduction in O_3 (blue colors) in the urban Los Angeles, and to a lesser extent, in the San Francisco Bay area. There are also increases in O_3 for the non-urban areas and for areas that are downwind of the major urban areas. For the 30 days simulated, there are increases in O_3 of 3 to 10 ppb in the 8-hour deployment case and increases of 13 to 19 ppb in the 24-hour deployment case. As discussed in Section 3.2.3, increases in O_3 of even a few ppb represent a significant portion of the O_3 budget and may adversely affect the O_3 attainment demonstrations contained in SIPs.

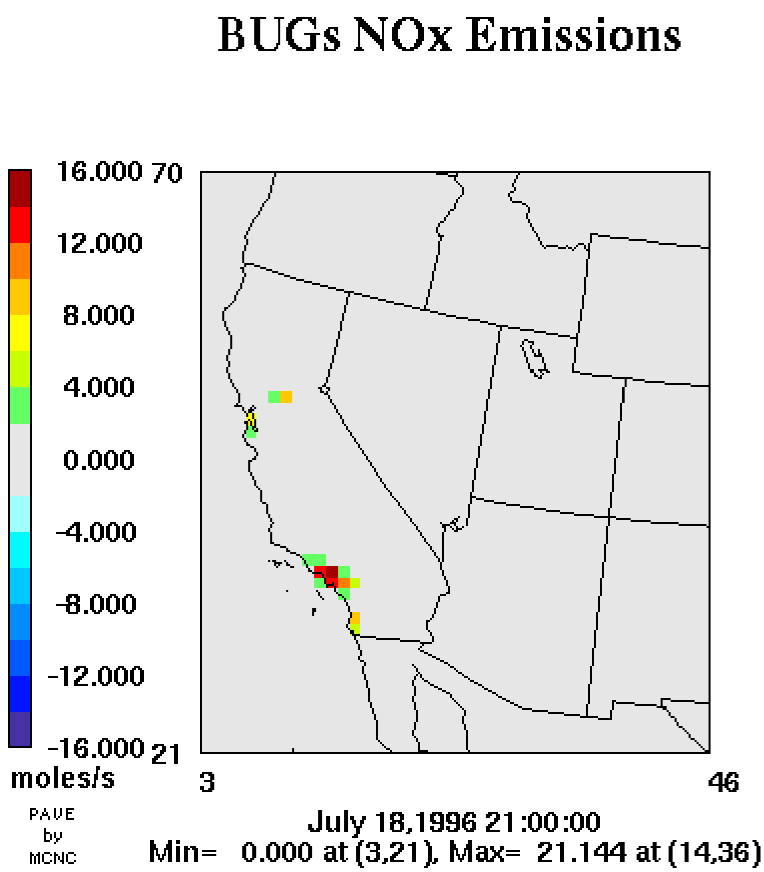


Figure 3-8. Emissions rate of nitrogen oxides (NO_X=NO+NO_2) from Backup Diesel Generators used for the 8-hr and 24-hr deployment scenarios. Note that 1 mole/s is equal to 1.3 metric tonnes per 8 hours or 4 metric tonnes per 24 hours.

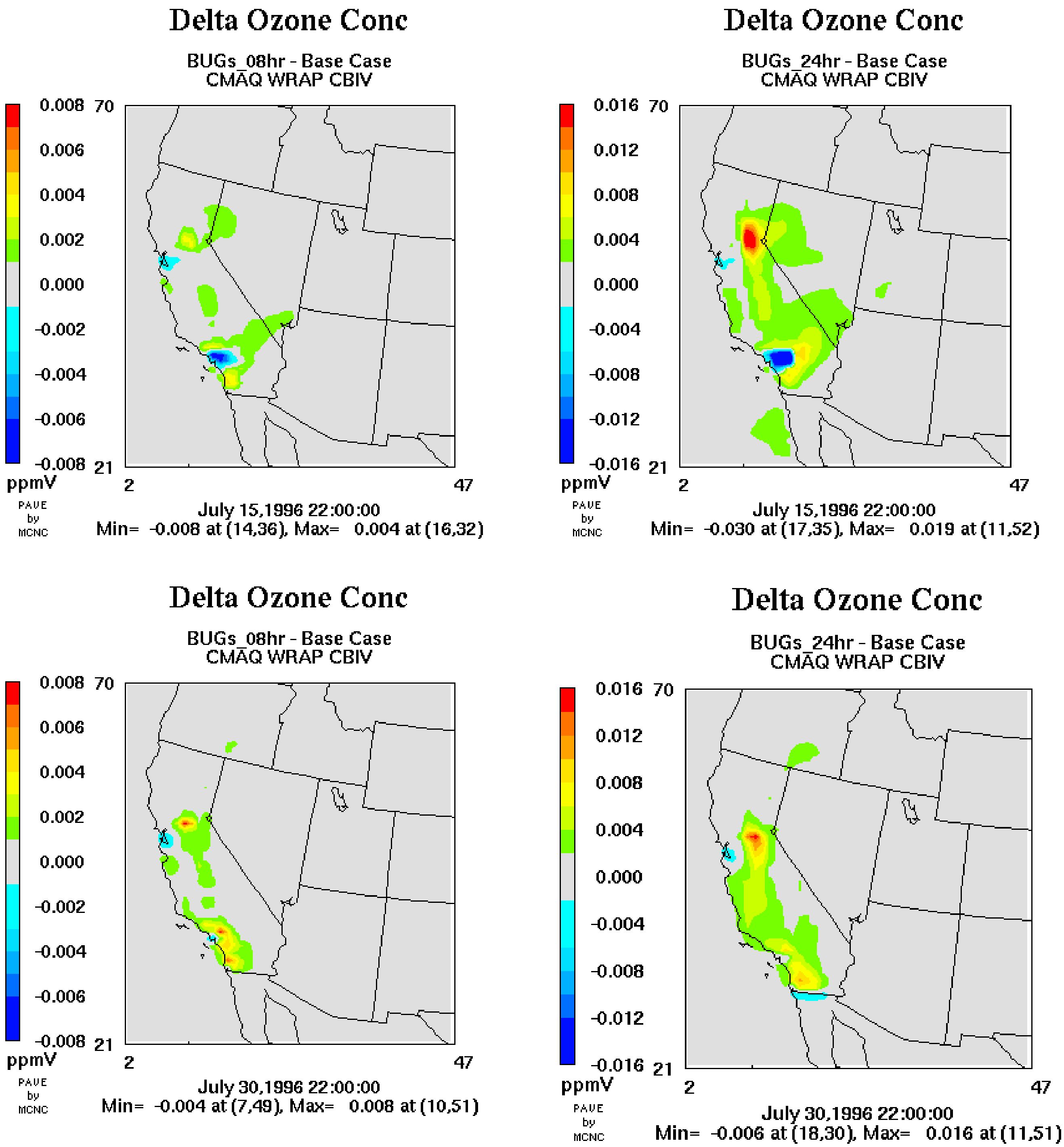


Figure 3-9. Example plots from regional modeling of BUGs effects of O_3 for 8-hour BUGs deployment (top) and 24-hour deployment (right), for July 27 (top) and July 28 (bottom).

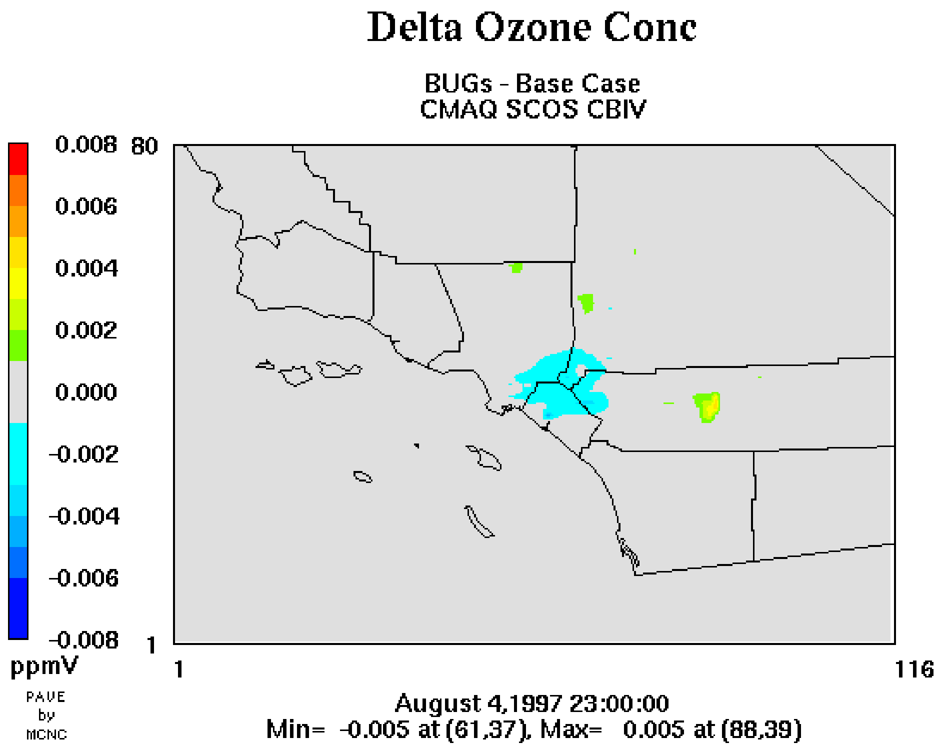
3.2.6. O_3 Modeling for Blackout Episode in Southern California

We performed O_3 modeling for a specific power blackout incident for May 8, 2001, using actual or estimated BUGs deployment data as described in Section 3.2.2. First, we performed a base case simulation using meteorological and emissions data for a model scenario prepared by the CARB and the South Coast Air Quality Management District (SCAQMD) for an O_3 episode during the SCOS 1997 field study. In our sensitivity simulation, we calculated the additional emissions for the BUGs deployment data for the May 8 incident, and we added these emissions to the base case for the 1997 episode. This approach is used for two reasons. First, considerable resources are required to prepare a model scenario, and it is not feasible to prepare the necessary emissions and meteorology inputs specifically for the May 8, 2001 incident. Second, and more important, our goal was to determine the effects of BUGs NO_X emissions on a day that already had moderate to high levels. Thus, our goal is not to determine the air quality effects on May 8, 2001, but rather to determine more generally the likely effects of BUGs NO_X emissions on O_3 levels for typical, high O_3 days.

The meteorology data was derived from MM5 simulations performed by the CARB. We used the SMOKE emissions processing system to prepare emissions input files from emissions data obtained from CARB for area, point, mobile, and biogenics emissions sources. Figure 3-10 shows the expected effects of BUGs emissions from the blackout incident as change in O_3 on the August 4 and August 5 simulations. The blue areas in the Figure 3-10 show reductions in O_3 as great as 5 ppb in the urban Los Angeles area. We note that the O_3 reductions occur in areas that had high NO_X and low O_3 in the base case simulation, and moreover, the reductions in O_3 are accompanied by increases in NO_2, so this should not be interpreted as an air quality benefit. The yellow areas in Figure 2-10 in western Riverside county show increases in O_3 as larges as 5 ppb. High O_3 concentrations occur much more frequently in western Riverside and San Bernardino counties; therefore, it is more likely that these increases could exacerbate existing O_3 attainment problems. For areas that typically have low O_3, such as coastal areas or downtown Los Angeles, an increase of 5 ppb O_3 might not be a cause for concern, because these areas tend to be well below the air quality standards. However, O_3 increases in areas downwind from Los Angeles (such as Riverside and San Bernardino counties) is a greater cause for concern, because these areas already exceed or are marginally in attainment of the O_3 standard, and a 5 ppb increase could cause an attainment area to exceed the O_3 standard.

Figure 3-11 shows changes in nitric acid (HNO_3) that would be expected to be caused by the BUGs blackout incident emissions on the August 5 and 6 scenario. As expected, HNO_3 increases or is unchanged throughout the model domain. We did not simulate $PM_{2.5}$ formation in this episode, because NH_3 emissions were not available. However, given that there is excess ambient ammonia (NH_3) in western Riverside county, it is likely that the increased HNO_3 production would lead to increases in ammonium nitrate and $PM_{2.5}$ as large as 1 $\mu g/m^3$ in some areas. Thus, these results indicate that formation of secondary $PM_{2.5}$ from photochemical reactions of the BUGs NO_X emissions is a concern and should be further investigated with high-resolution model scenarios that are capable of simulating $PM_{2.5}$.

Because the NAAQS attainment criteria for O_3 is based on the second highest observed O_3 level for a three-year average, if BUGs were used to routinely make up power shortages on high demand days, based on the model scenarios presented here, it is likely that the BUGs emissions would occasionally occur on high O_3 days. This situation could result in O_3 increases that would either cause a marginally high O_3 day to exceed the NAAQS, or it could cause an increase in the emissions reduction required from other source categories for a day that already exceeded the NAAQS.



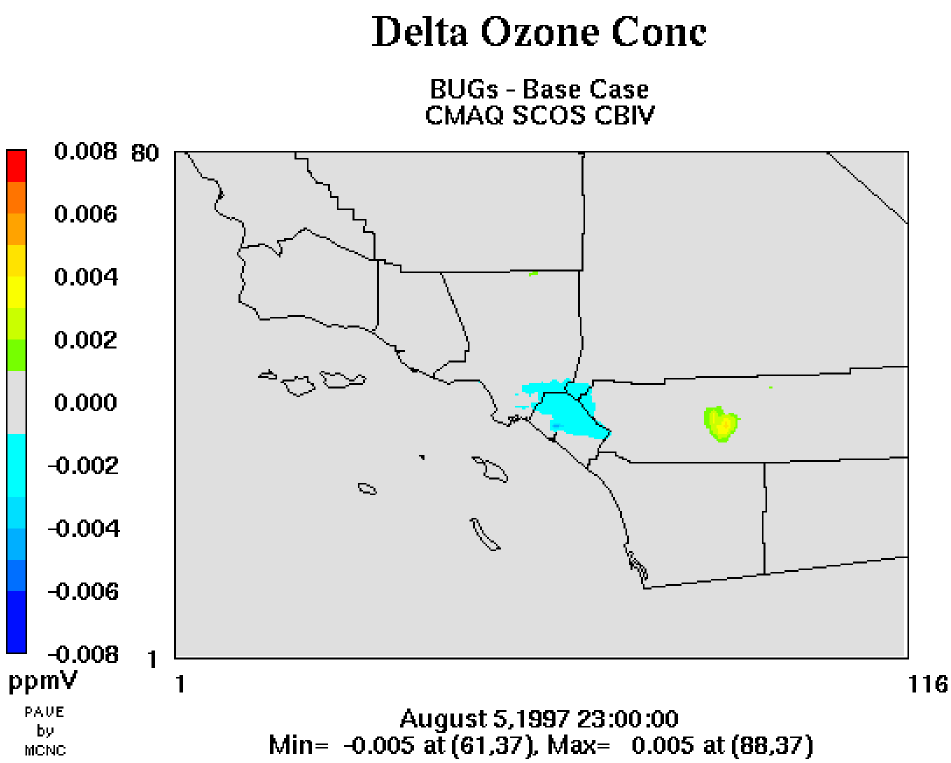
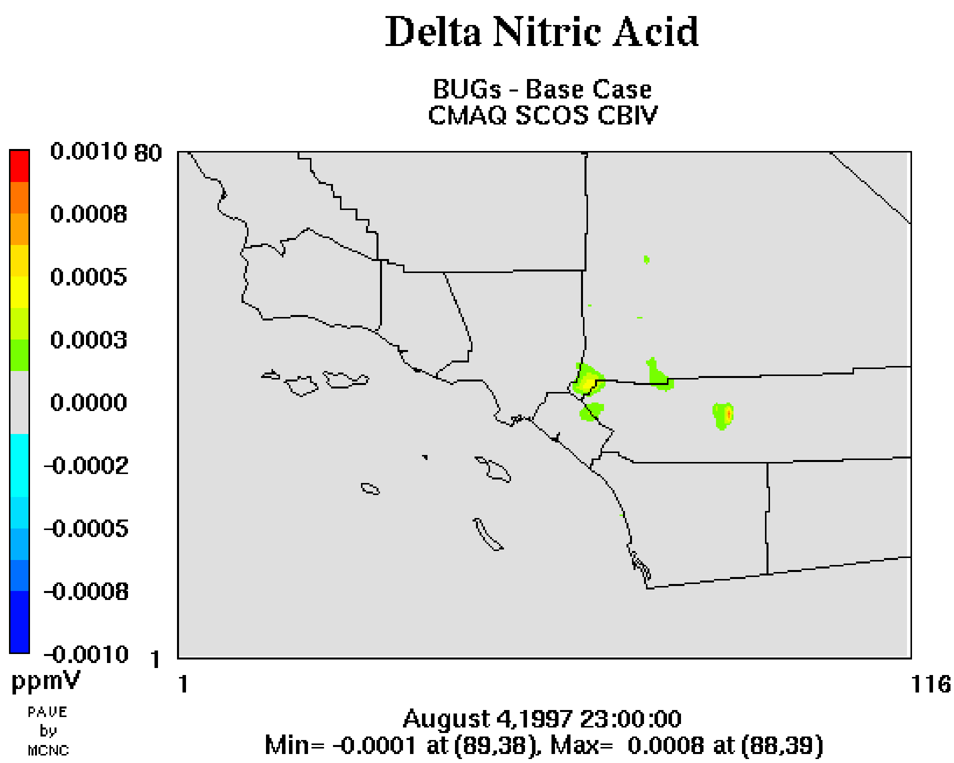


Figure 3-10. Change in ozone concentration compared to the base case



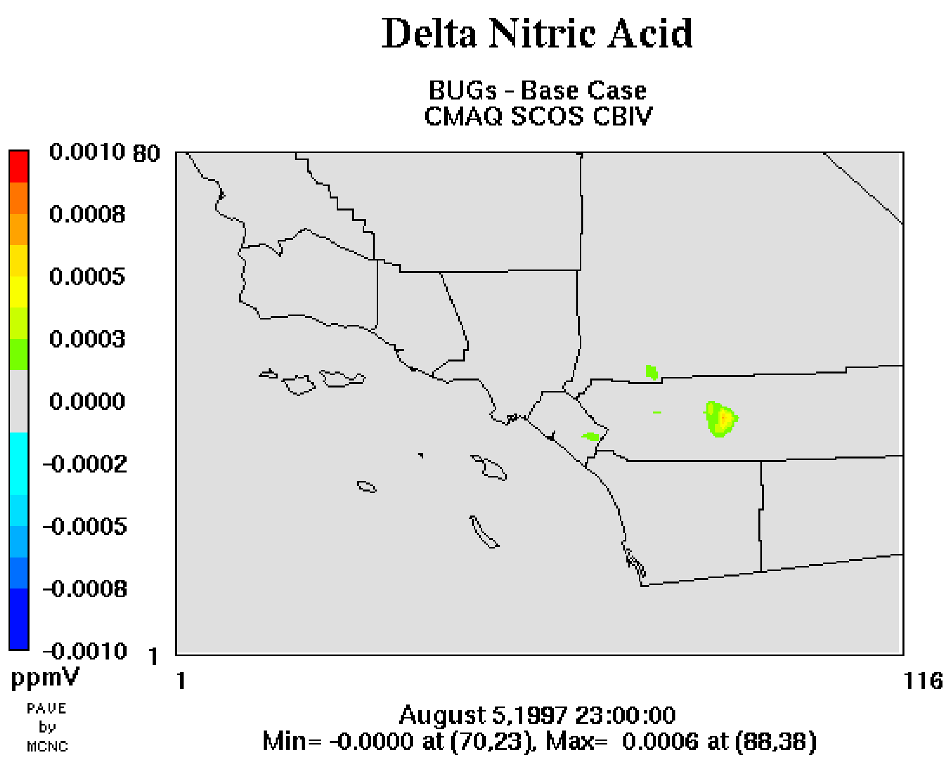


Figure 3-11. Change in nitric acid concentration compared to the base case

4.0 Health Risk Assessment

4.1. Introduction

In addition to the regional air quality issues discussed in Section 3, BUGs deployment has the potential to adversely affect the air quality in the immediate vicinity. Impacts of concern include the health risks associated with increased NO_2 and PM_{10} levels. The significance of the potential impacts depends, in general, on:

- Local meteorology
- Local land use
- Building configuration
- Stack parameters of the BUG (stack height, exhaust gas temperature and velocity)
- Emission rates of the BUG
- Deployment schedule
- Population density in the vicinity of the BUG
- Local terrain

In this project, we assessed the impacts from several hypothetical deployment scenarios, using estimated emission rates and dispersion modeling to help gain a better understanding of the potential magnitude of the local impacts and the relationship between these impacts and the parameters listed above.

Local air quality impacts were assessed using the EPA's Industrial Source Complex Short Term (ISCST3) Dispersion Model to determine potential ambient concentrations of NO_2 and PM_{10}. For modeling purposes, all NO_X is assumed to be NO_2. This is an overly cautious assumption, because NO_X emissions are primarily in the form of nitric oxide (NO), which is not a criteria pollutant. However, NO can be rapidly converted to NO_2 in ambient air when there is excess O_3. Because the chemical conversion of NO to NO_2 cannot be represented in the ISCST3 model, we used the overly cautions assumption that all NO was converted to NO_X. This approach was used because we expected that it was unlikely that NO_2 standards would be exceeded, and we wanted to test this hypothesis under a worst-case (i.e., 100% NO_2) scenario.

The modeled concentrations of NO_2 and PM_{10} were used to determine the individual lifetime cancer risk and a hazard index (HI), the ratio of predicted concentration to the relevant standard. All modeling results are presented as cancer risk and hazard index isopleths[13], as well as a tabulation of maximum distance to benchmark cancer risks and hazard indices. An estimation of excess cancer burden was determined for a representative urban/industrial location and a rural location.

13. An *isopleth* is plot showing contour lines of constant O_3 concentration.

4.2. Scenarios

To assess the effects of local meteorology on the associated air quality impacts, modeling was performed with two meteorological data sets representing “worst case” and “typical” meteorological scenarios. From these scenarios, it is possible to extrapolate the impacts of actual BUG operation events.

Local land-use affects the dispersion of the plume, because land use is assumed to be an indicator of surface roughness. The surface roughness affects the dispersion parameters used to estimate the Gaussian dispersion. An urban land use is assumed to have a greater surface roughness (due to buildings and other structures), and therefore increased dispersion, as compared with rural land-use. The increased dispersion results in a larger, less concentrated plume, i.e., lesser maximum concentrations but broader impact areas. To assess the effects of local land use parameters on the associated air quality impacts, modeling was performed with both the urban dispersion parameters and the rural dispersion parameters.

Wind blowing across a building or other structure causes a well-mixed wake or cavity region downwind of the structure. A plume released within the vicinity of the structure, either upwind or downwind, will become entrained in the wake region and mix down to the ground. This phenomenon is known as *downwash.* Downwash can greatly increase ground-level pollutant concentrations within the wake region of a building or other structure. Many BUGs are located at industrial facilities or in other urban environments with significant potential for downwash to occur. To assess the effects of surrounding building configuration on the associated air quality impacts modeling was performed with and without building downwash.

To assess the effects of emission rates and release parameters on the associated air quality impacts two different sized BUGs were modeled. It is assumed that BUGs of a similar size will display similar emission and release characteristics.

To assess the effects of the deployment schedule on the associated air quality impacts, two schedules were modeled. The first schedule is 24 hours per day, 365 days per year for 70 years. Although this is an unrealistic deployment schedule, the results can be used as a point of comparison for other more plausible schedules. The second modeled schedule represents a more realistic deployment schedule: 11 a.m. to 7 p.m. every day during the summer months only, for 70 years. For both deployment scenarios we used a 70-year period to determine the lifetime exposure risk.

Although actual deployment of any given BUG will not likely be for the full duration of these schedules, the resulting impacts are scalable by the percent of total hours operated, assuming the operation is within the given deployment schedule. If a given BUG is operated for one-third of the total summer hours during the 8-hour schedule, the resulting impacts will be one-third of those reported for that time schedule. However, because the dispersion of the emissions is Gaussian and not linear, the areas encompassed by a risk isopleth will not scale this way.

To assess the effects of the local population density on the associated air quality impacts, the population cancer burden was determined for two areas: one representing a rural area, and the other an urban/industrial area.

Local terrain can affect the ground-level concentrations predicted by the Industrial Source Complex Short-Term (ISCST) model. The effects of complex terrain were not considered for this study.

4.3. Modeling

All dispersion modeling was performed with the EPA's ISCST3 dispersion model.

4.3.1. Emission Rates and Release Parameters

Emission rates were calculated for two BUGs: a 750-kw generator and a 2000-kw generator. Hourly emission rates for diesel particulate matter and NO_X are derived from the BUGs emissions testing program. The emission rates and release parameters for these BUGs, one 750 kW and one 2000 kW, are shown on Table 4-1.

Emission factors were used to model the 8-hour scenarios. An emission factor of 1.0 was used for the hours of operation for each scenario, as described above. An emission factor of zero was used for the other 16 hours of the day.

Release parameters were determined from the BUGs testing results. Some data gaps were filled with data from manufacturers specifications and staff experience. All relevant release parameters are shown on Table 4-1.

Table 4-1. Emission parameters of two typical BUGs

Manufacturer	Caterpillar	Caterpillar
Capacity (kW)	750	2000
$PM_{2.5}$ emission rate (g/s)	0.05	0.13
NO_X emission rate (g/s)	1.67	4.23
Stack height (m)	2.54	3.81
Stack diameter (m)	.178	.356
Exhaust gas velocity ($m\ s^{-1}$)	74.2	42.5
Gas exhaust rate ($m^3\ s^{-1}$)	1.84	4.22
Exhaust gas temperature (°K)	750	750

The ISCST model predicts a wake region based on building geometry, relative stack location, and wind direction. If the stack is located within the affected region surrounding a building, the dispersion parameters are adjusted to account for the enhanced dispersion within the wake region.

Some scenarios include the consideration of building downwash for those BUGs situated in the vicinity of a building or other structure. For those scenarios, a building was situated in a square shape completely surrounding the BUG, with the BUG located in a square annular area or "courtyard."

All model runs were performed with the regulatory default option, without plume depletion or pollutants decay. All terrain was considered flat. Default temperature and wind speed profiles were used.

4.3.2. Meteorology

West Los Angeles 1981 and Burbank 1981 meteorological data from the SCAQMD were used. The SCAQMD has performed extensive modeling of typical sources using meteorological data from areas throughout the District. Results of this modeling have been used to develop a meteorological "factor" for use in screening risk assessments. The larger the factor, the greater the resulting ground-level concentration and associated risk. These factors range from 0.47 to 1.0 for sources operating less than 12 hours per day. The West Los Angeles data, with a factor of 1.0, was chosen as the "worst case" data. The primary reason for the relatively large predicted impacts associated with this data set is the consistency of direction, especially during the daytime hours, of the winds at this location (on the west-facing coast of the Los Angeles Basin). The Burbank data, with a factor of 0.57, was chosen because this data produces more intermediate results due to less consistency in the wind direction at this location.

4.3.3. Benchmarks

The metrics used for potential health risk impacts are:

- Comparison of predicted ambient NO_2 concentrations to new source review prevention of significant deterioration increment, 1 $\mu g/m^3$
- Comparison of Diesel exhaust PM_{10} concentration to the California Reference Exposure Limit (REL) for particulate emissions from diesel-fueled engines
- Estimation of individual excess cancer risk associated with inhalation of diesel exhaust
- Estimation of population cancer burden associated with inhalation of diesel exhaust

4.4. Cancer Risk and Cancer Burden Calculations

Individual excess cancer risk is the increase in the probability that an individual will contract cancer due to a given exposure. Population cancer burden is the total number of excess cancer cases expected as a result of a given exposure.

Risks were calculated based on the predicted diesel particulate exposure concentration and the CARB unit risk factor for particulate emissions from diesel-fueled engines. All risks were calculated assuming a 70-year residential exposure scenario.

Cancer burden was calculated based on the impact area defined as the area exposed to an individual cancer risk greater than one-in-a-million. The population density was assumed to be uniform throughout the impact area. The individual cancer risk at any location was interpolated from the dispersion model results. The individual cancer risk was integrated over the impact area to estimate the population cancer burden.

4.5. Results

The California Reference Exposure Level (REL) for particulate matter from diesel-fueled engines is 5 μg/m³. The REL is a metric for chronic, non-cancer risk, and exposure to levels less than the REL are not expected to result in adverse health effects. The excess individual lifetime cancer risk associated with the California REL for particulate matter from diesel-fueled engines, 5 μg/m³, is 1,500 in a million. Because this excess individual lifetime cancer risk is much greater than the acceptable threshold of one in a million, the chronic risk associated with exposure to particulate matter from diesel-fueled engines is not significant compared to the cancer risk, therefore further evaluation of the REL was not completed.

All modeling results are summarized on Tables 4-2 and 4-3, and are presented as contour diagrams in the series of figures provided in Appendix C. Figures 3-1 through 3-18 in Appendix C show the one in a million and ten in a million cancer risk isopleths for nine scenarios each for the large and medium BUGs. Figures 3-19 to 3-36 show the 1 μg/m³ NO_2 isopleth for the same scenarios. The areas encompassed by the one-in-a-million cancer risk and the 1 μg/m³ NO_2 isopleths are shown on Tables 4-2 and 4-3.

Table 4-2. Health impacts of medium BUGs

Scenario						**Area of isopleth (Square kilometers)**		**Population cancer burden (excess lifetime cancer cases)**		
Scenario I.D.	Meteorology	Downwash	Dispersion	Size	Hours per Day	1 in a Million Cancer Risk	NO_2 = 1 μg/m³	Urban/Industrial High – 7,000/km²	Urban/Industrial Ave – 4,000/km²	Rural 70/km²
M1	BUR	Y	R	M	8	3.9	0.3	*0.082*	*0.047*	0.001
M2	WLA	Y	R	M	8	6.3	0.4	*0.123*	*0.070*	0.001
M3	BUR	N	R	M	8	3.6	0.2	*0.044*	*0.025*	0.000
M4	WLA	N	R	M	8	6.0	0.3	*0.082*	*0.047*	0.001
M5	BUR	Y	U	M	8	1.2	0.1	0.037	0.021	*0.000*
M6	WLA	Y	U	M	8	2.1	0.2	0.070	0.040	*0.001*
M7	BUR	N	U	S	8	1.2	0.1	0.022	0.013	*0.000*
M8	WLA	N	U	S	8	2.1	0.2	0.040	0.023	*0.000*
M9	WLA	Y	U	S	24	141.9	6.9	2.138	1.222	*0.021*

Note: BUR stands for Burbank meteorology, WLA stands for West Los Angeles meteorology, Y stands for yes, N stands for no, R stands for rural, U stands for urban, M stands for medium, and L stands for large.

The impact area for the 8-hour scenarios ranged from 1.2 square kilometers (km^2) to 6.3 km^2 for the medium-sized BUG; and 3.4 km^2 to 15.3 km^2 for the large BUG. The impact area for the 24-hour scenario was 466 km^2 and 142 km^2 for the large and medium BUG, respectively.

The estimated population cancer burdens for the 8-hour scenarios range from < 0.001 to 0.123 for a medium BUG and from 0.001 to 0.258 for a large BUG. The 24-hour scenario produced a population cancer burden that ranged from 2.138 for the high population density assumption to .021 for the rural population density assumption for the medium BUG. The 24-hour scenario produced a population cancer burden that ranged from 7.705 for the high population density assumption to .077 for the rural population density assumption for the large BUG.

Table 4-3. Health impacts of large generator

Scenario						**Area of isopleth (Square kilometers)**		**Population cancer burden (excess lifetime cancer cases)**		
Scenario I.D.	Meteorology	Downwash	Dispersion	Size	Hours per Day	1 in a Million Cancer Risk	NO_2 = 1 Ug/m^3	Urban/Industrial High – 7,000/km^2	Urban/Industrial Ave – 4,000/km^2	Rural 70/km^2
L1	BUR	Y	R	L	8	11.4	0.6	*0.178*	*0.051*	0.002
L2	WLA	Y	R	L	8	15.3	0.8	*0.258*	*0.074*	0.003
L3	BUR	N	R	L	8	10.4	0.3	*0.112*	*0.032*	0.001
L4	WLA	N	R	L	8	15.0	0.7	*0.223*	*0.064*	0.002
L5	BUR	Y	U	L	8	3.5	0.3	0.095	0.027	*0.001*
L6	WLA	Y	U	L	8	10.3	0.4	0.178	0.051	*0.002*
L7	BUR	N	U	L	8	3.4	0.2	0.057	0.016	*0.001*
L8	WLA	N	U	L	8	10.3	0.4	0.120	0.034	*0.001*
L9	WLA	Y	U	L	24	465.7	22.3	7.705	2.201	*0.077*

Note: BUR stands for Burbank meteorology, WLA stands for West Los Angeles meteorology, Y stands for yes, N stands for no, R stands for rural, U stands for urban, M stands for medium, and L stands for large.

For the 8-hour scenario, the area encompassed by the prevention of significant deterioration (PSD) increment, 1 $\mu g/m^3$ NO_2, isopleth ranged from 0.1 km^2 to 0.4 km^2 for the medium BUG; and 0.2 to 0.8 for the large BUG. For the 24-hour scenario, the area encompassed by the 1 $\mu g/m^3$ NO_2 isopleth was 6.9 km^2 and 22.3 km^2 for the medium and large BUG respectively.

A comparison of even-numbered scenarios to odd-numbered scenarios indicates that the West Los Angeles meteorological data produces impacts much greater in the downwind direction and much narrower in the crosswind direction due to consistent wind direction. The total impact area for the West Los Angles scenarios is consistently larger than the impact area for the Burbank scenarios.

A comparison of Scenarios L1–L4 with scenarios L5–L8 and scenarios M1–M4 to scenarios M5–M8 indicates that rural dispersion parameters produce isopleths much larger in the downwind distance but narrower in the crosswind distance, as is expected with reduced dispersion parameters. The total impact area of the rural scenarios is consistently greater than that of the urban scenarios. The relevant population cancer burdens are much less for the rural scenarios, due to the reduced population density.

A comparison of scenarios with downwash to the equivalent scenario without downwash indicates the presence of a building in the vicinity of a BUG will result in larger impacts within the first few hundred meters of the source. The impacts with and without a building present begin to converge at distances greater than several hundred meters.

A comparison of Scenarios M1–M7 with L1–L7 indicates, as is expected, the smaller emission rate associated with the medium BUG results in less impacts in general. The reduced release velocity, however, sometimes may result in larger impacts very close to the BUG, because the plume will touch ground at a shorter downwind distance. This is demonstrated by a comparison of scenarios L4 and M4, shown on Figures 3-4 and 3-13 in Appendix C, respectively.

Although results are available for only a limited range of deployment schedules, a comparison of Scenarios M6 and L6 to M9 and L9 indicates the 24-hour scenario will result in much larger impacts. This is due to the increased emissions associated with operation over the entire year for 24 hours per day. The increase in predicted impacts is somewhat mitigated by the fact that the wind direction is not nearly as consistent for the 24-hour scenario as the 8-hour scenario. It is expected that a shorter daily schedule than 8-hours will not result in a further narrowing of wind direction. In that case impacts will become more nearly linearly proportional to total operating hours.

4.6. Population Demographics

The population cancer burden associated with exposure to a BUG's emissions is very largely dependant on the population distribution in the vicinity of the BUG. Demographic data for the State of California from the 2000 U.S. Census was analyzed to gain a better understanding of the potentially exposed population in the vicinity of existing BUGs. The Census provides population demographic data at several different resolutions or groupings. Three of the commonly used are the block, block group, and tract. A block typically represents one physical block, bounded by four streets. One to several blocks comprises a block group and one to several block groups comprises a tract.

Two analyses were performed; both used demographic data from the Census 2000 Summary File 1 at the block group level. This data includes the following categories used for these analyses:

- Total population, divided into White, Black, Asian, Hawaiian or Pacific Islander, American Indian or Native Alaskan and Other, Hispanic

- Age under 17 (derived from age under 5 and age 5 to under 17)
- Age over 65

The first analysis compares the populations potentially affected by a BUG to California's population as a whole. The data used to represent populations affected by a BUG are the census demographic data for the block group where the BUG is located. The data used to represent the State's populations are the census data for the State's block groups as a whole. The second analysis provides a more detailed comparison of two case studies, using actual BUG locations and sizes and the BUG-dependent shape of the model-predicted impact zones. Potentially exposed populations were analyzed for two different existing bugs at different locations: one in Burbank, and one in West Los Angeles.

The average size of the State's block groups is 19 km^2. The median size is 0.5 km^2. The average size of the block groups surrounding a BUG is 68 km^2, the median size is 1.5 km^2. (All analyses of block groups surrounding a BUG are BUG-weighted, i.e., if two BUGs are located in a given block group, that tract is considered twice in the analysis). The size of the cancer risk isopleths ranged from 1 to 15 km^2 for the 8-hour scenario and from 141 to 465 km^2 for the 24-hour scenario.

One or more of the State's 4,058 BUGs are located in 1,639 of the State's 22,133 block groups. The median population density of the State's block groups is 2,538 people per square kilometer. The median density of the block groups containing a BUG is 952 people per square kilometer. Table 4-4 compares population demographics for the State's block groups and block groups surrounding BUGs. Inspection of Table 4-4 indicates that the demographic make-up of the populations in the vicinity of BUGs includes 46.2 % non-white persons, compared to 40.5% for the State as a whole. This represents a 12% increase of non-white population in the vicinity of a BUG. Figure 4-1 shows the location of the 4,058 BUGs in California. Figure 4-2 shows the population density by block group for the State of California.

A demographic analysis was performed for two case studies, using actual BUGs located in West Los Angeles and Burbank. For each location, the cancer risk isopleth predicted for the BUG was overlaid onto the census block groups as shown on Figures 4-3 and 4-4 for the West Los Angeles and Burbank BUG, respectively. Population demographics for the block groups and partial block groups encompassed by the one-in-a-million cancer risk isopleth were determined. (Populations for partial block groups were based on the fraction of area encompassed by the risk isopleth.) A summary of this analysis is shown on Table 4-4. A detailed listing of population demographics by block group for the impacted area is shown on Tables 4-5 and 4-6 for the West Los Angeles and Burbank BUG, respectively. Figure 4-5 shows the relation between the population demographics for the State as a whole, the block groups containing a BUG, the West Los Angeles impact zone, or the area encompassed by the one-in-a-million cancer risk isopleth, and the Burbank impact zone.

Table 4-4. Comparison of statewide and BUGs population demographics (as percent of total population)

	BUGs (%)	State Avg. (%)	West LA (%)	Burbank (%)
WHITE	53.8	59.5	52.8	66.5
BLACK	8.5	6.7	18.4	2.4
AMERICAN NATIVE	0.9	1.0	0.5	0.5
ASIAN	14.1	10.9	11.6	10.8
HAWAIIAN/PACIFIC ISLANDER	0.3	0.3	0.2	0.2
OTHER	17.4	16.8	11.1	12.7
MULTI-RACE	5.0	4.7	5.5	6.9
HISPANIC	33.2	32.4	21.3	30.7
MALES	51.1	49.8	48.0	48.0
FEMALES	48.9	50.2	52.0	52.0
UNDER 18	21.8	27.3	19.0	23.3
OVER 65	12.4	10.6	11.1	12.7

Table 4-5. West Los Angeles impact zone population demographics for the 1-in-a-million risk and 10-in-a-million risk isopleths for the year 2000. (Units are numbers of persons in the impact zone defined by the risk level.)

TRACT	GRP	Risk Level	Percent Block Group	Total Population	White	Black	American Indian	Asian	Hawaiian	Other	Multi-Ethnic	Hispanic	<18 Years	65 Years and Older
702801	3	1.0E-06	7.04%	194.2	90.8	14.2	2.3	28.5	0.3	45.2	13.0	84.2	48.6	22.2
702801	3	1.0E-06	8.00%	220.5	103.1	16.1	2.6	32.4	0.3	51.3	14.7	95.6	55.2	25.2
271801	4	1.0E-06	18.25%	180.6	102.4	8.0	2.9	17.3	0.0	39.0	10.9	73.9	34.7	17.0
271801	4	1.0E-06	9.69%	95.9	54.4	4.3	1.6	9.2	0.0	20.7	5.8	39.2	18.4	9.0
702801	1	1.0E-06	29.60%	341.3	212.3	13.6	1.2	67.2	0.9	26.6	19.5	74.3	82.0	34.9
702801	1	1.0E-06	10.85%	125.1	77.8	5.0	0.4	24.6	0.3	9.8	7.2	27.2	30.1	12.8
271802	3	1.0E-06	53.29%	906.0	398.1	69.8	3.2	219.6	2.1	137.5	75.7	268.6	191.3	53.3
271802	3	1.0E-06	33.10%	562.7	247.3	43.4	2.0	136.4	1.3	85.4	47.0	166.8	118.8	33.1
702501	3	1.0E-06	20.73%	254.6	169.0	14.3	2.7	28.0	0.8	24.7	15.1	55.1	42.5	25.7
702501	1	1.0E-06	58.07%	158.5	117.9	4.1	2.3	18.6	0.6	10.5	4.6	29.0	22.6	16.8
271802	2	1.0E-06	77.68%	2472.4	1070.4	312.3	14.8	540.6	10.1	325.5	198.9	615.2	382.9	112.6
269902	3	1.0E-06	30.35%	1154.4	498.3	153.0	10.6	210.3	0.6	209.4	72.2	396.0	190.9	51.0
269901	2	1.0E-06	0.10%	4.5	1.9	0.8	0.0	0.8	0.0	0.7	0.3	1.3	0.7	0.2
271802	2	1.0E-06	22.32%	710.6	307.6	89.7	4.2	155.4	2.9	93.5	57.2	176.8	110.1	32.4
269902	3	1.0E-06	46.66%	1775.1	766.2	235.2	16.3	323.4	0.9	322.0	111.1	609.0	293.5	78.4
269901	3	1.0E-06	100.00%	555.0	261.0	69.0	1.0	110.0	1.0	72.0	41.0	177.0	70.0	26.0
271802	1	1.0E-06	35.15%	382.7	229.9	25.3	4.2	73.5	0.4	34.1	15.5	75.9	62.2	46.7
269902	3	1.0E-06	22.99%	874.5	377.5	115.9	8.0	159.3	0.5	158.6	54.7	300.0	144.6	38.6
271701	3	1.0E-06	1.97%	30.8	18.0	3.0	0.1	6.0	0.0	1.5	2.2	4.2	4.2	2.2
702400	5	1.0E-06	61.93%	503.5	317.1	58.8	1.2	50.8	2.5	49.5	23.5	112.7	88.6	68.1
702400	4	1.0E-06	39.41%	517.1	300.7	40.6	3.5	53.2	0.0	74.9	44.1	156.5	110.4	48.5
269902	2	1.0E-06	90.22%	1329.8	684.7	162.4	19.8	209.3	0.0	185.8	67.7	376.2	169.6	146.1
269901	2	1.0E-06	99.90%	4616.6	1936.1	782.3	49.0	796.2	6.0	720.3	326.7	1341.7	727.3	219.8
269902	1	1.0E-06	6.40%	126.2	67.3	15.6	0.6	24.9	0.4	10.2	7.2	19.3	13.7	6.2
269901	1	1.0E-06	89.94%	2473.5	1103.6	429.0	26.1	414.6	9.0	334.6	156.5	587.3	382.3	114.2
702400	3	1.0E-06	40.84%	499.1	282.2	22.9	5.3	51.9	2.9	102.5	31.4	197.3	122.5	48.6
270100	2	1.0E-06	100.00%	3726.0	1550.0	777.0	19.0	730.0	10.0	416.0	224.0	707.0	485.0	152.0
270100	1	1.0E-06	100.00%	893.0	317.0	161.0	1.0	207.0	1.0	142.0	64.0	214.0	122.0	36.0
702400	2	1.0E-06	43.91%	553.7	280.1	40.0	7.5	63.7	2.2	130.0	30.3	248.5	145.8	42.2
702400	1	1.0E-06	0.50%	0.9	0.3	0.1	0.0	0.2	0.0	0.3	0.0	0.5	0.2	0.1

Table 4-5 (continued).

TRACT	GRP	Risk Level	Percent Block Group	Total Population	White	Black	American Indian	Asian	Hawaiian	Other	Multi-Ethnic	Hispanic	<18 Years	65 Years and Older
269800	2	1.0E-06	100.00%	669.0	343.0	65.0	3.0	161.0	1.0	53.0	43.0	133.0	88.0	51.0
270200	2	1.0E-06	100.00%	1115.0	466.0	66.0	2.0	173.0	12.0	335.0	61.0	622.0	291.0	75.0
269800	1	1.0E-06	100.00%	2191.0	822.0	419.0	23.0	402.0	5.0	344.0	176.0	659.0	432.0	90.0
269000	5	1.0E-06	78.14%	765.8	565.8	31.3	0.0	75.0	0.0	70.3	23.4	161.8	137.5	165.7
269000	6	1.0E-06	15.08%	39.5	34.2	0.8	0.5	2.6	0.0	0.2	1.4	2.1	8.6	8.1
269700	5	1.0E-06	100.00%	1303.0	494.0	255.0	19.0	165.0	4.0	282.0	84.0	560.0	339.0	38.0
270200	1	1.0E-06	100.00%	1735.0	683.0	149.0	13.0	116.0	6.0	645.0	123.0	1179.0	535.0	79.0
270300	3	1.0E-06	53.55%	573.5	189.6	130.7	4.3	12.3	18.7	175.6	42.3	330.4	166.0	47.7
269800	3	1.0E-06	100.00%	505.0	377.0	32.0	3.0	60.0	0.0	21.0	12.0	49.0	101.0	89.0
269000	4	1.0E-06	100.00%	769.0	625.0	19.0	3.0	77.0	0.0	19.0	26.0	52.0	142.0	190.0
269700	2	1.0E-06	100.00%	83.0	34.0	6.0	0.0	14.0	0.0	23.0	6.0	39.0	12.0	4.0
269700	4	1.0E-06	100.00%	632.0	345.0	60.0	5.0	79.0	0.0	87.0	56.0	171.0	122.0	72.0
269000	3	1.0E-06	37.03%	179.9	161.1	0.7	0.0	5.9	0.4	3.0	8.9	9.3	42.2	34.4
270300	4	1.0E-06	7.33%	71.9	14.1	35.4	0.4	2.2	0.0	15.9	3.8	28.6	19.6	7.4
269700	1	1.0E-06	100.00%	1517.0	491.0	349.0	4.0	111.0	15.0	461.0	86.0	698.0	388.0	127.0
269700	3	1.0E-06	100.00%	681.0	459.0	80.0	2.0	49.0	2.0	71.0	18.0	155.0	104.0	81.0
269500	2	1.0E-06	100.00%	661.0	563.0	11.0	0.0	64.0	0.0	9.0	14.0	29.0	138.0	153.0
269000	2	1.0E-06	55.99%	418.8	376.3	1.1	0.0	26.3	0.0	2.2	12.9	26.9	100.8	82.3
270300	2	1.0E-06	62.39%	504.7	100.4	282.6	1.2	26.8	1.2	71.1	21.2	124.8	111.7	69.9
269600	2	1.0E-06	100.00%	2394.0	587.0	728.0	12.0	59.0	0.0	855.0	153.0	1399.0	860.0	69.0
270300	1	1.0E-06	100.00%	570.0	106.0	278.0	0.0	29.0	0.0	140.0	17.0	187.0	157.0	54.0
269600	4	1.0E-06	100.00%	2150.0	749.0	641.0	28.0	91.0	4.0	476.0	161.0	929.0	570.0	99.0
269600	1	1.0E-06	100.00%	1918.0	342.0	806.0	10.0	36.0	1.0	645.0	78.0	978.0	682.0	67.0
269500	3	1.0E-06	71.25%	1002.5	918.4	17.1	0.0	29.9	0.0	11.4	25.7	38.5	288.6	190.2
269500	4	1.0E-06	7.40%	29.4	28.3	0.1	0.1	0.1	0.0	0.3	0.4	0.4	8.4	6.1
269600	3	1.0E-06	100.00%	299.0	221.0	37.0	2.0	21.0	2.0	2.0	14.0	12.0	59.0	38.0
269500	1	1.0E-06	100.00%	861.0	738.0	18.0	1.0	74.0	1.0	13.0	16.0	36.0	246.0	122.0
216700	2	1.0E-06	58.04%	336.1	90.0	186.9	3.5	15.1	0.0	26.1	14.5	50.5	73.1	47.0
269500	5	1.0E-06	73.57%	416.4	390.6	5.1	1.5	13.2	0.0	1.5	4.4	8.1	139.0	61.8
216700	3	1.0E-06	100.00%	536.0	138.0	251.0	4.0	26.0	0.0	72.0	45.0	120.0	123.0	59.0
217000	5	1.0E-06	100.00%	489.0	250.0	129.0	0.0	41.0	0.0	44.0	25.0	70.0	84.0	53.0

Table 4-5 (continued).

TRACT	GRP	Risk Level	Percent Block Group	Total Population	White	Black	American Indian	Asian	Hawaiian	Other	Multi-Ethnic	Hispanic	<18 Years	65 Years and Older
217000	4	1.0E-06	100.00%	514.0	380.0	50.0	0.0	39.0	0.0	15.0	30.0	39.0	112.0	60.0
216700	1	1.0E-06	8.76%	128.7	25.6	79.4	0.7	5.7	0.2	12.5	4.6	23.7	28.0	15.6
217000	3	1.0E-06	100.00%	582.0	427.0	39.0	28.0	40.0	2.0	12.0	34.0	85.0	133.0	55.0
269100	2	1.0E-06	10.02%	135.9	126.7	2.1	0.0	4.1	0.0	0.3	2.6	2.6	33.7	24.8
217000	2	1.0E-06	92.22%	782.9	665.8	44.3	3.7	20.3	0.0	15.7	33.2	65.5	196.4	79.3
217000	1	1.0E-06	4.62%	44.7	36.3	1.4	0.2	2.1	0.1	1.6	2.9	2.8	11.8	6.7
216700	4	1.0E-06	87.64%	1162.1	449.6	469.8	2.6	67.5	2.6	98.2	71.9	187.6	212.1	227.0
216800	4	1.0E-06	3.46%	27.0	21.4	2.8	0.0	0.9	0.1	0.7	1.2	1.8	2.9	4.1
217000	6	1.0E-06	100.00%	1277.0	745.0	257.0	4.0	80.0	0.0	88.0	103.0	190.0	195.0	107.0
217000	7	1.0E-06	83.42%	1708.5	1160.4	161.8	5.0	143.5	0.0	51.7	186.0	128.5	287.0	247.8
216400	3	1.0E-06	0.07%	1.6	1.2	0.1	0.0	0.1	0.0	0.1	0.2	0.1	0.2	0.3
216400	2	1.0E-06	6.84%	129.5	96.4	8.0	0.1	12.6	0.1	4.0	8.2	11.3	17.5	18.5
Total		*1.0E-06*	*NA*	*58,149.5*	*27,780.3*	*9,892.8*	*403.3*	*7,236.2*	*135.4*	*9,108.7*	*3,592.9*	*16,826.5*	*12,068.9*	*4,696.8*
Total Percent		*1.0E-06*	*NA*	*100.0%*	*47.8%*	*17.0%*	*0.7%*	*12.4%*	*0.2%*	*15.7%*	*6.2%*	*28.9%*	*20.8%*	*8.1%*

TRACT	GRP	Risk Level	Percent Block Group	Total Population	White	Black	American Indian	Asian	Hawaiian	Other	Multi-Ethnic	Hispanic	<18 Years	65 Years and Older
702801	3	1.0E-05	8.00%	220.5	103.1	16.1	2.6	32.4	0.3	51.3	14.7	95.6	55.2	25.2
271801	4	1.0E-05	18.25%	180.6	102.4	8.0	2.9	17.3	0.0	39.0	10.9	73.9	34.7	17.0
702801	1	1.0E-05	10.85%	125.1	77.8	5.0	0.4	24.6	0.3	9.8	7.2	27.2	30.1	12.8
271802	3	1.0E-05	53.29%	906.0	398.1	69.8	3.2	219.6	2.1	137.5	75.7	268.6	191.3	53.3
271802	2	1.0E-05	77.68%	2472.4	1070.4	312.3	14.8	540.6	10.1	325.5	198.9	615.2	382.9	112.6
269901	2	1.0E-05	0.10%	4.5	1.9	0.8	0.0	0.8	0.0	0.7	0.3	1.3	0.7	0.2
269902	3	1.0E-05	46.66%	1775.1	766.2	235.2	16.3	323.4	0.9	322.0	111.1	609.0	293.5	78.4
Total		*1.0E-05*	*NA*	*5,684.2*	*2,519.8*	*647.1*	*40.2*	*1,158.7*	*13.8*	*885.8*	*418.7*	*1,690.8*	*988.4*	*299.5*
Total Percent		*1.0E-06*	*NA*	*100.0%*	*44.3%*	*11.4%*	*0.7%*	*20.4%*	*0.2%*	*15.6%*	*7.4%*	*29.7%*	*17.4%*	*5.3%*

Table 4-6. Burbank impact zone population demographics for the 1-in-a-million risk and 10-in-a-million risk isopleths. (Units are numbers of persons in the impact zone defined by the risk level.)

TRACT	GRP	Risk Level	Percent Block Group	Total Population	White	Black	American Indian	Asian	Hawaiian	Other	Multi-Ethnic	Hispanic	<18 Years	65 Years and Older
311800	3	1.0E-06	0.0	112.8	66.3	5.4	0.7	10.0	0.5	23.1	6.8	53.7	31.1	6.8366
310800	2	1.0E-06	0.1	71.7	53.9	2.0	1.1	4.3	0.1	5.7	4.5	14.2	13.5	11.356
311800	3	1.0E-06	0.0	1.6	0.9	0.1	0.0	0.1	0.0	0.3	0.1	0.7	0.4	0.0951
310900	7	1.0E-06	0.1	91.9	74.8	0.7	0.9	7.3	0.0	4.9	3.4	17.0	19.6	17.166
310900	6	1.0E-06	0.0	38.1	28.9	0.3	0.2	4.0	0.1	3.2	1.4	8.4	8.8	5.1628
310800	2	1.0E-06	0.2	113.8	85.6	3.2	1.8	6.8	0.2	9.1	7.2	22.6	21.4	18.032
311000	4	1.0E-06	0.0	6.1	4.7	0.1	0.0	0.4	0.0	0.7	0.2	1.5	1.6	0.777
310800	1	1.0E-06	0.2	193.7	126.9	4.2	2.5	10.2	0.0	41.2	8.5	93.5	46.5	15.993
310702	2	1.0E-06	0.2	408.4	274.5	9.4	1.8	63.0	0.7	23.6	35.4	69.1	59.2	129.42
310701	2	1.0E-06	0.1	57.6	46.5	0.6	0.1	1.3	0.1	2.1	6.8	8.7	2.4	41.318
310900	2	1.0E-06	0.9	1177.7	871.6	27.2	11.1	125.8	0.0	86.7	55.3	265.3	249.1	147.95
310702	2	1.0E-06	0.4	699.3	470.0	16.1	3.1	107.9	1.2	40.3	60.7	118.3	101.4	221.58
311000	3	1.0E-06	0.6	875.2	653.2	12.8	4.6	67.8	4.6	82.9	49.3	237.6	209.2	106.06
310800	1	1.0E-06	0.7	533.1	349.5	11.7	6.9	28.2	0.0	113.5	23.4	257.3	128.0	44.027
310702	1	1.0E-06	0.5	2140.0	1407.6	71.2	11.2	244.3	1.5	197.5	206.7	466.6	425.7	186.25
310701	2	1.0E-06	0.9	424.4	342.5	4.4	0.9	9.7	0.9	15.9	50.2	64.3	17.6	304.68
311000	2	1.0E-06	1.0	898.6	658.7	16.0	5.0	103.0	4.0	66.0	46.0	267.9	200.9	114.95
310900	3	1.0E-06	1.0	905.0	623.0	8.0	12.0	79.0	2.0	115.0	66.0	324.0	242.0	102
310900	1	1.0E-06	1.0	1133.0	801.0	11.0	1.0	130.0	2.0	131.0	57.0	411.0	266.0	116
310900	4	1.0E-06	0.9	1215.2	890.4	28.7	4.6	86.1	0.0	160.1	45.4	391.5	301.7	149.01
310701	1	1.0E-06	1.0	1661.6	1105.8	40.6	4.0	244.3	3.0	130.6	133.5	353.1	391.7	146.38
311000	1	1.0E-06	1.0	557.0	352.0	13.0	0.0	78.0	6.0	97.0	11.0	242.0	165.0	66
311100	1	1.0E-06	0.3	550.6	370.5	4.5	2.8	56.4	0.7	88.1	27.5	235.1	151.5	68.602
310500	2	1.0E-06	0.6	483.6	217.3	11.5	7.8	29.6	0.0	175.1	42.3	343.5	164.8	28.978
310500	3	1.0E-06	0.1	137.7	71.8	4.1	1.6	7.2	0.3	43.0	9.7	87.1	45.3	5.2833
310600	2	1.0E-06	1.0	1000.9	771.5	24.4	2.9	88.9	1.0	65.4	46.9	206.0	189.4	166.99
310500	1	1.0E-06	0.7	500.4	307.4	4.3	2.2	31.1	0.0	130.2	25.3	300.8	156.2	40.498
310200	5	1.0E-06	0.4	1091.7	717.7	16.7	2.3	184.2	1.1	76.3	93.4	185.7	230.5	117.34
310200	6	1.0E-06	0.0	9.1	7.7	0.1	0.0	0.7	0.0	0.1	0.6	0.9	2.1	1.4905
310600	5	1.0E-06	0.5	1085.0	682.5	35.5	3.2	150.2	1.6	135.6	76.4	324.5	255.7	99.031

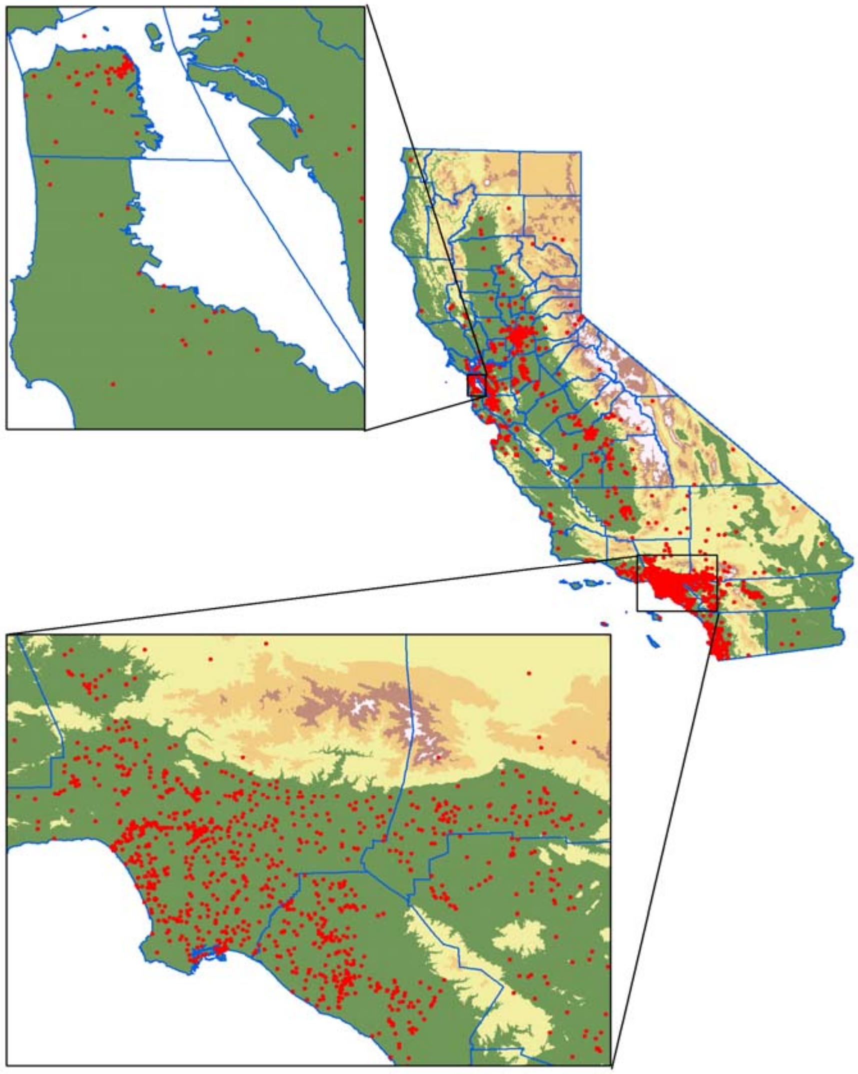


Figure 4-1. Location of BUGs in California

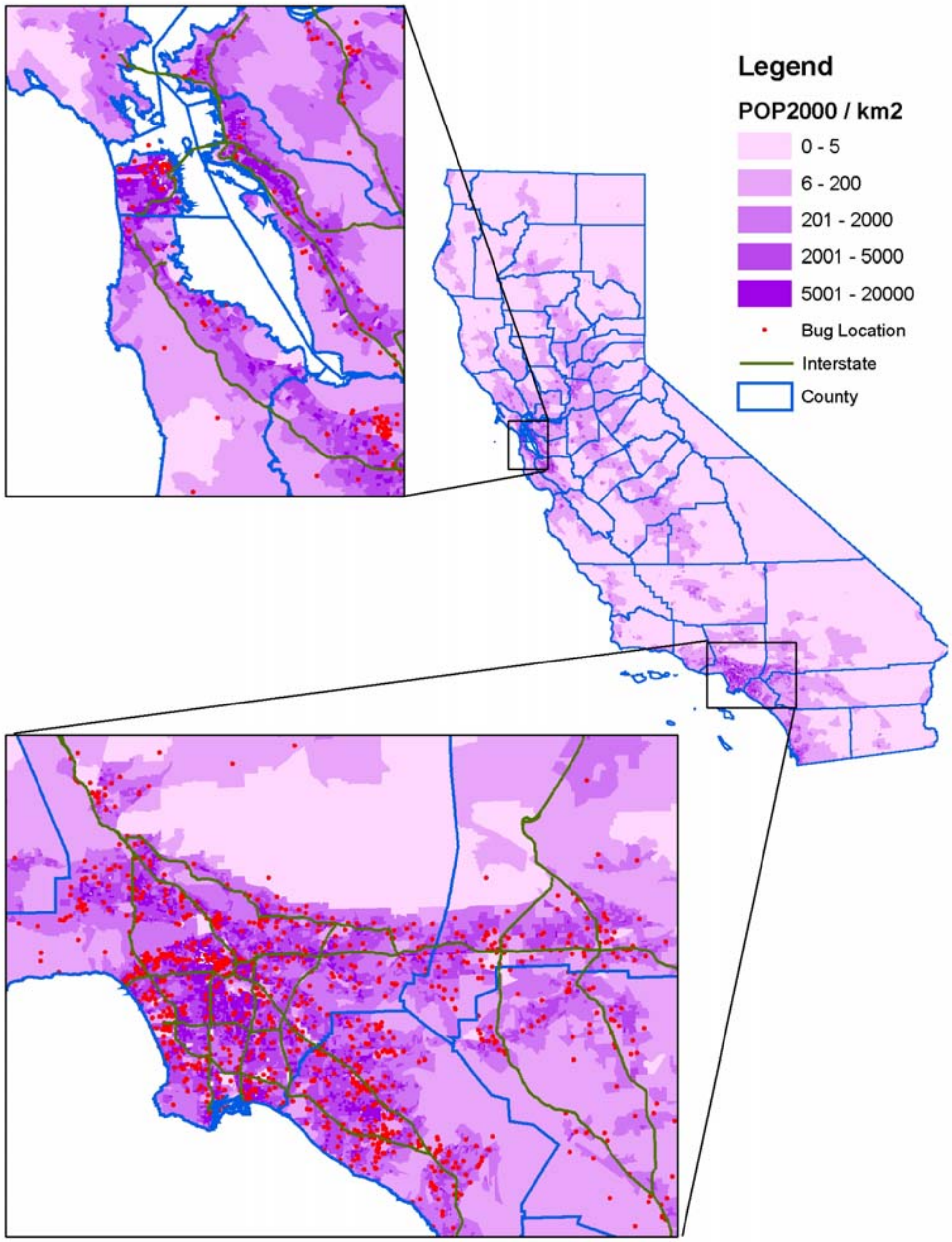


Figure 4-2. Total population density by block group

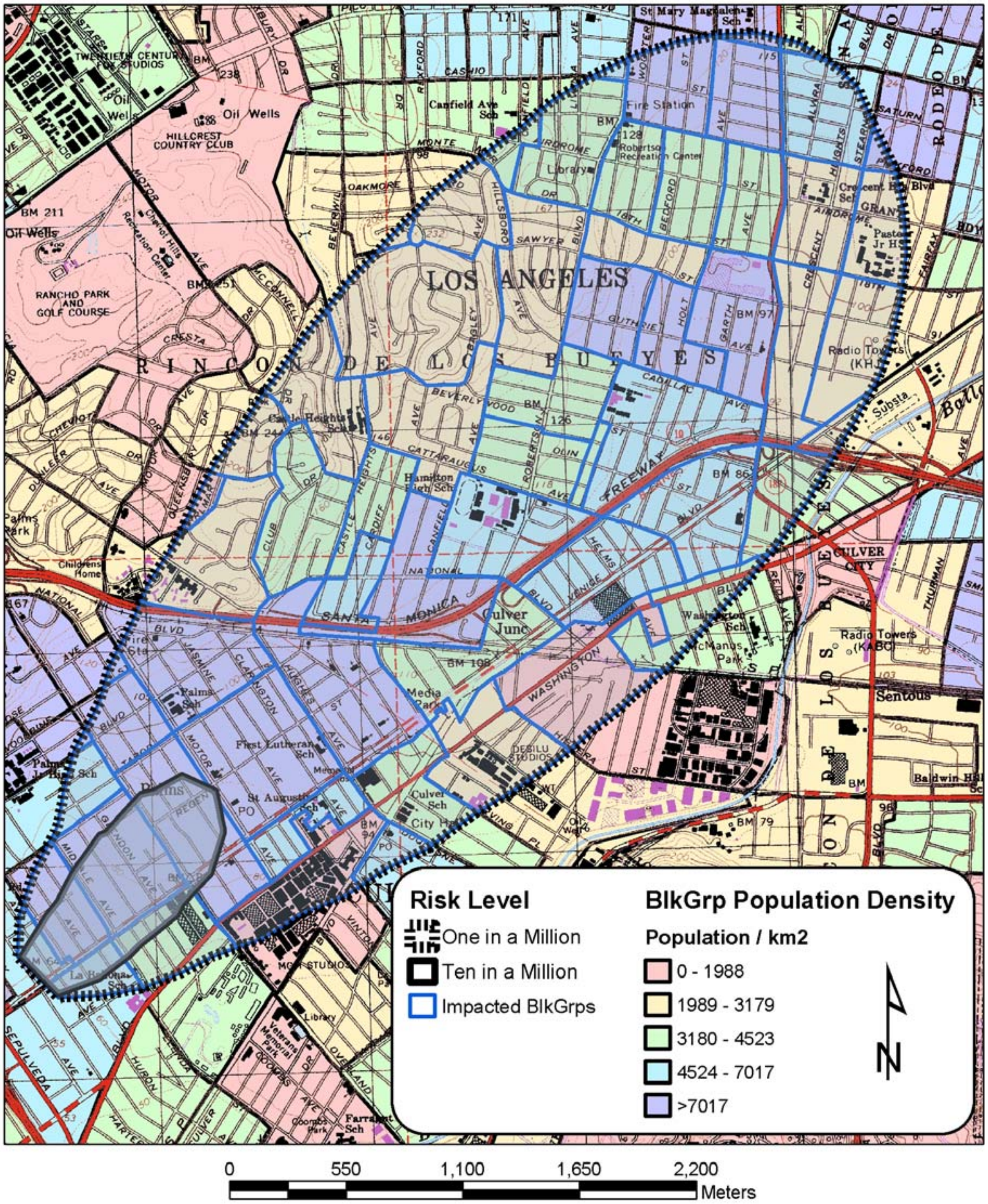


Figure 4-3. West Los Angeles impact zone with demographics

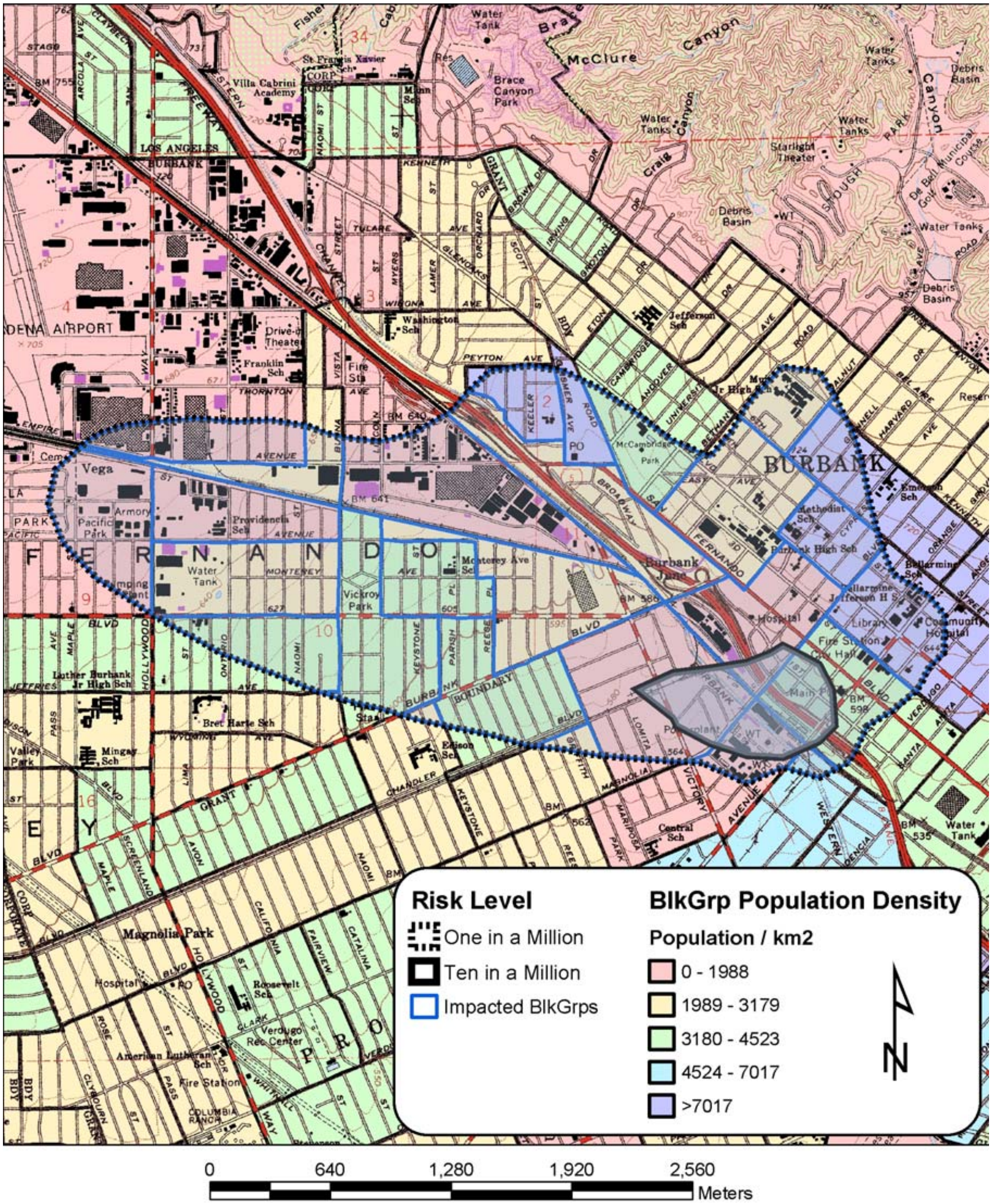


Figure 4-4. Burbank impact zone with demographics

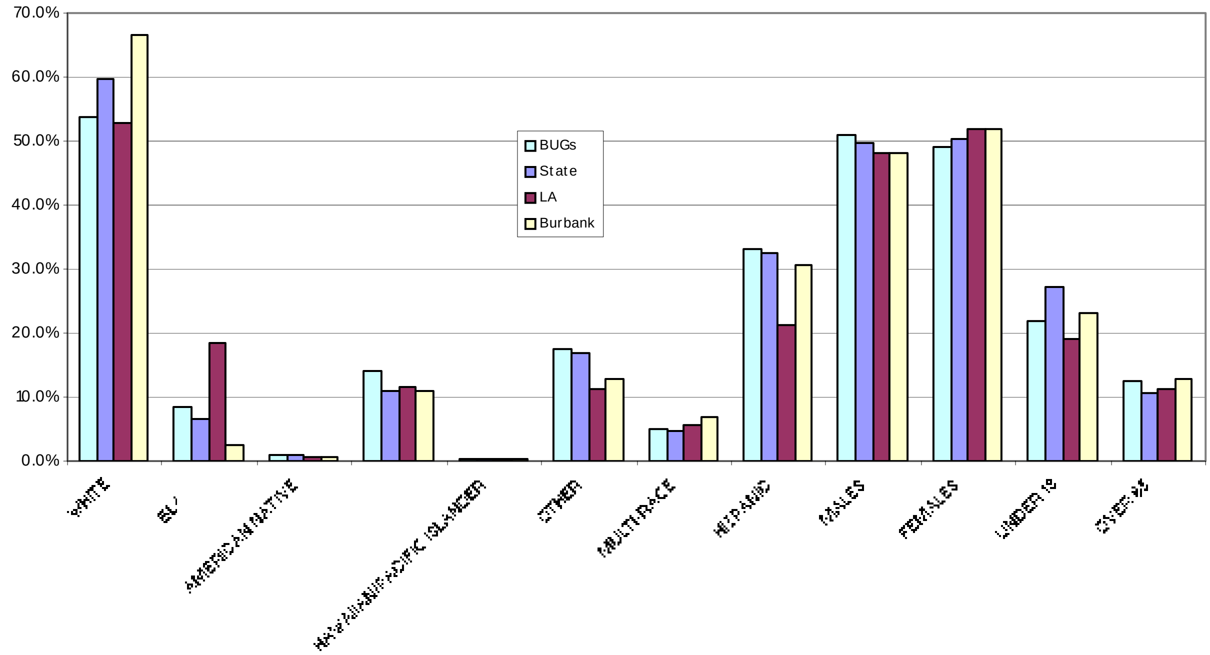


Figure 4-5. Demographic comparison

4.7. Conclusions

Of the three health-risk metrics considered—individual cancer risk, NO_2 exposure, and population cancer burden—the individual cancer risk appears to be of most concern. Based on an 8-hour summer (June, July, and August) operating schedule for a BUG, individual lifetime cancer risk impacts could exceed acceptable impacts within several hundred meters, or even several kilometers of the BUG. Areas affected at levels exceeding the PSD) increment for NO_2—a very stringent standard—never exceed 1 km^2.

Results from both meteorological data sets for all scenarios indicate that care should be taken to understand the actual wind direction at the exact site of the BUG, which may be different from a nearby meteorological station because of terrain or "street canyon" effects. Modeling results indicate that for the Burbank meteorology and urban dispersion parameters, the impact area is contained within one quadrant of the area surrounding the BUG. For the West Los Angeles meteorology and rural dispersion parameters, the impact area is contained within half of a quadrant.

The presence of buildings near a BUG will greatly increase the impacts within the first couple of hundred meters.

The significance level for population cancer burden defined by many State and local regulations, including California Assembly Bill 2588 (AB 2588, Connelly, Chapter 1252, Statutes of 1987), is 0.5 total excess cancer cases per million. Estimated cancer burdens associated with BUGs deployment are less than the 0.5 significance level for all of the 8-hour per day operations. But some do approach 0.25 and one is 0.28. These levels should not be dismissed since they are half of the acceptable level. On the other hand, the 24-hour per day operations scenarios for the urban cases all exceed the 0.5 significance level (actually exceed 1). Thus, if BUGs are operated 24-hours per day rather than 8-hours per day then clearly there is a concern with air pollution risk.

Appendix C contains details of the assumptions and more plots of the results of population exposure, as well as the local dispersion scenarios discussed in Section 4.2.

5.0 BUG Emissions Measurement

5.1. BUG Emission Factors: Literature Review

The emissions estimates made for the May 8, 2001, power outage were based on emission factors from the literature. Table 5-1 shows the range of values found in the literature. This table is repeated in Appendix A.

Table 5-1. Range of emission rates from literature search

Pollutant	Low Range (g/kWh)	High Range (g/kWh)
NO_X	2.68	7.76
PM	0.34	1.36
CO_2	672.19	771.07
CO	3.45	13.61
VOC	0.33	0.91
SO_2	0.14	0.23

These factors were used for the analysis in Tables 1-10a and 1-10b because significant time was required to develop the testing matrix, recruit the BUGs, and conduct the baseline emissions measurements. Most of the baseline measurements now are complete, and some tests with emission control technologies also have been completed, as discussed in the following subsections. These preliminary results are provided for information only; a more detailed report upon completion of the measurement program will describe the protocols, quality assurance, and other features of the research in detail.

5.2. CE-CERT Baseline Emissions Measurements from BUGs

As of this report, most of the baseline emissions tests on uncontrolled BUGs have been completed. Results from 5 BUGs and 28 tests were used to develop the emission rates used in this analysis. Table 5-2 lists the BUGs tested to date in this program. The emissions tests conducted thus far were used to develop emission rates used in the atmospheric modeling as described in Section 4 (Appendix A describes the process used to establish emission factors.) Testing of additional BUGs are underway. Emission results did not seem to show an effect from manufacturer, age, or model, but did show a variation with load. Therefore, emissions were categorized by operating load and engine type (2-stroke or 4-stroke) only.

Table 5-2. BUGs used to develop emission rate estimates

Location	Make	Model	VIN/Serial #	Generator Type	Max Power kW
Johnson Mach	CAT 3412C	3412 C	BPG00177	Primary	545
VAFB	CAT 3406C	3406 C	4RG01632	Backup	300
VAFB	DETROIT 92	80837405	BVF149700	Backup	350
SB University	CAT 3406C	3406 C	4JK00753	Primary	350
Johnson 340xx 350	CAT 3406	3406 C	4JK00706	Primary	350

Figure 5-1 shows NO_X emissions in grams per kilowatt-hour (g/kWh) for the units tested so far. Figure 5-2 shows particulate emissions. Generally, we do show that particulate emission rates decline with the age of the BUG, presumably reflecting that the newer units are conforming with newer emission control requirements.

In the baseline testing, we also have been measuring for numerous toxic species of interest, including formaldehyde, acetaldehyde, acrolein, acetone, propionaldehyde, crotonaldehyde, methacrolein, methyl ethyl ketone (MEK), butyraldehyde, benzaldehyde, valeraldehyde, tolualdehyde, and hexaldehyde. A detailed analysis of the toxics is continuing. Figure 5-3 shows formaldehyde emissions (expressed in milligrams per kilowatt-hour generated) from four of the units tested.

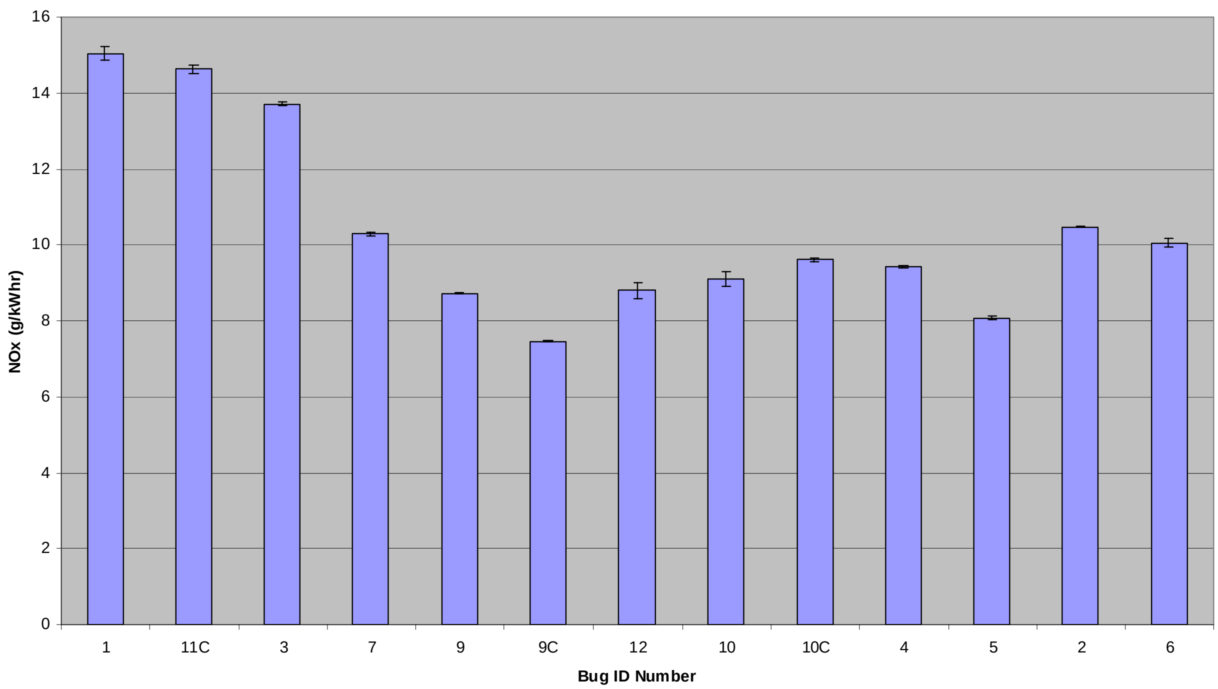


Figure 5-1. Baseline NOX emissions from all units tested so far[14]

---

14. BUGs are indicated by ID number. Appendix 1 contains emission variations by operating load for all pollutants.

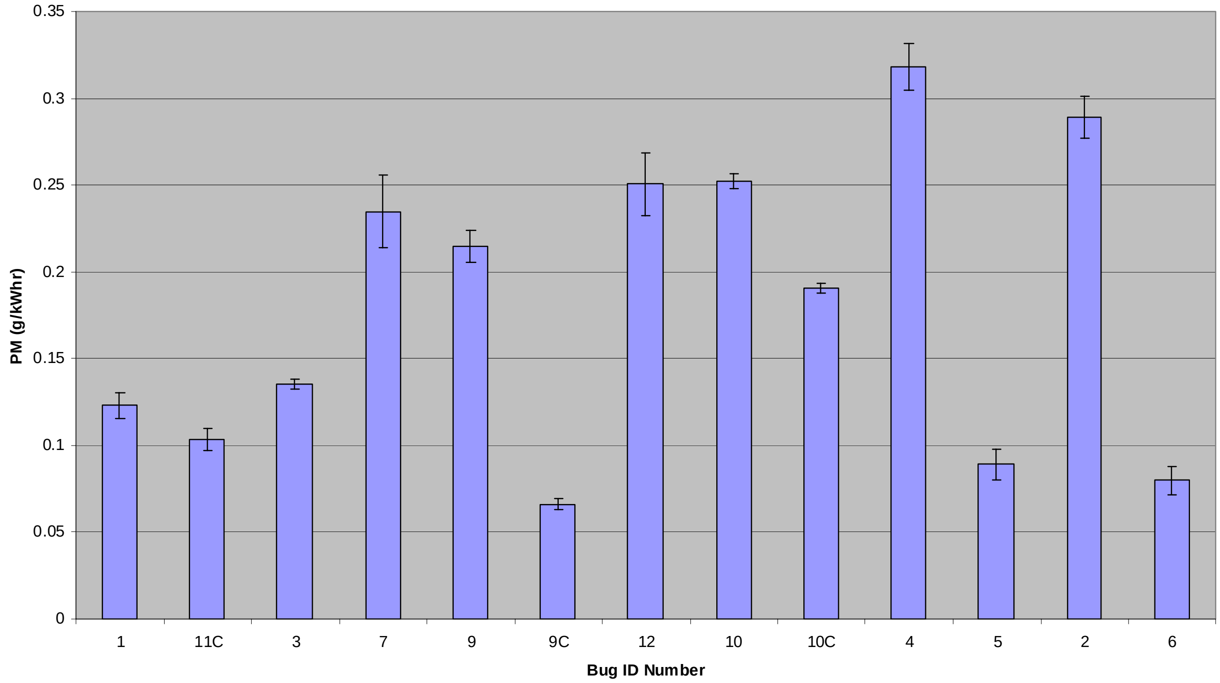


Figure 5-2. Baseline particulate emissions from all units tested so far[15]

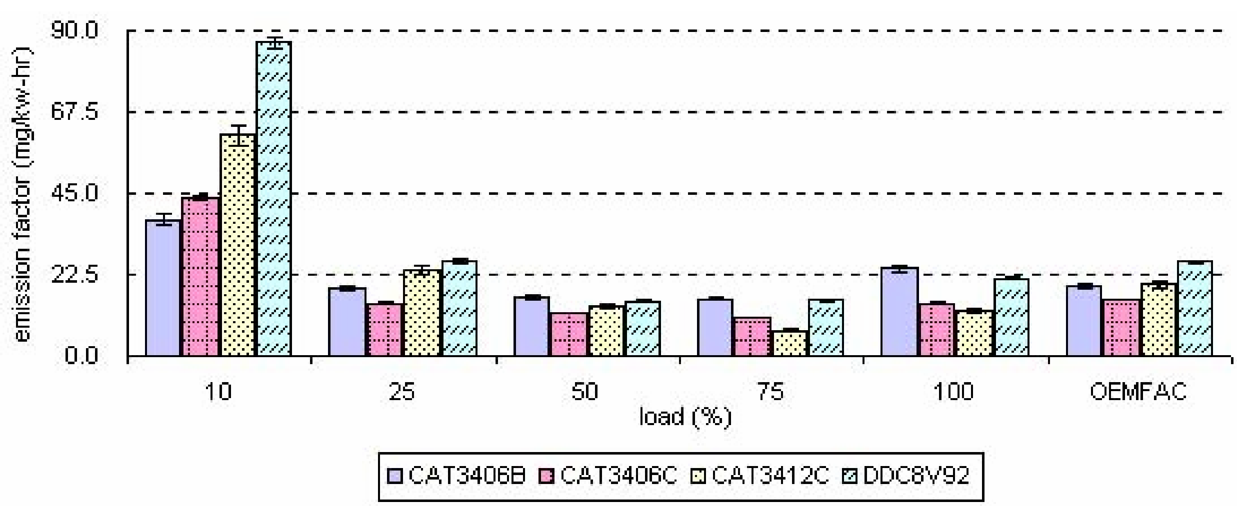


Figure 5-3. Formaldehyde emission factors for four BUGs[16]

---

15. BUGs are indicated by ID number. Appendix 1 contains emission variations by operating load for all pollutants.

16. OEMFAC in the figure refers to estimates made by the CARB EMFAC emissions estimation software.

Table 3.5 summarizes the emissions in pounds per megawatt-hour (lb/MW/hr) from 4-stroke diesel generators. These emission rates were used in the air quality modeling. The italicized blue values indicate emissions were estimated outside of the testing range. Since SO_2 emissions were not measured in the CE-CERT tests, SO_2 emissions from Table 1 were used in the air quality analysis.

Table 5.3. Summary of emission factors used in atmospheric modeling[17]

Load	VOC	THC	CH_4	CO	NO_X	CO_2	PM
kW	lb/MWh	Lb/MWh	lb/MWh	lb/MWh	lb/MWh	lb/MWh	lb/MWh
100	0.463	0.546	0.088	4.51	26.54	2003.01	0.457
200	0.249	0.282	0.062	3.70	21.64	1715.34	0.457
300	0.177	0.193	0.053	3.43	20.00	1619.45	0.457
400	0.142	0.149	0.049	3.29	19.19	1571.50	0.457
500	0.120	0.123	0.046	3.21	18.70	1542.74	0.457
600	*0.106*	*0.105*	*0.044*	*3.16*	*18.37*	*1523.56*	*0.457*
800	*0.088*	*0.083*	*0.042*	*3.09*	*17.96*	*1499.59*	*0.457*
1000	*0.077*	*0.070*	*0.041*	*3.05*	*17.72*	*1485.20*	*0.457*
1200	*0.070*	*0.061*	*0.040*	*3.02*	*17.55*	*1475.61*	*0.457*
1600	*0.061*	*0.050*	*0.039*	*2.99*	*17.35*	*1463.63*	*0.457*
2000	*0.056*	*0.043*	*0.038*	*2.97*	*17.23*	*1456.44*	*0.457*

5.3. Measurements with Control Technologies

So far, we have quantified emissions from selected BUGs with a water-emulsion diesel fuel and with a diesel oxidation catalyst. Figures 5-4 and 5-5 show the change in NO_X and particulate emissions from two BUGs with the water-emulsion fuel. Figures 5-6 and 5-7 show the changes in NO_X and particulate emissions from two BUGs with the diesel oxidation catalyst. None of these data were used in the modeling.

17. A full discussion of the development of the emission factors can be found in Appendix 1.

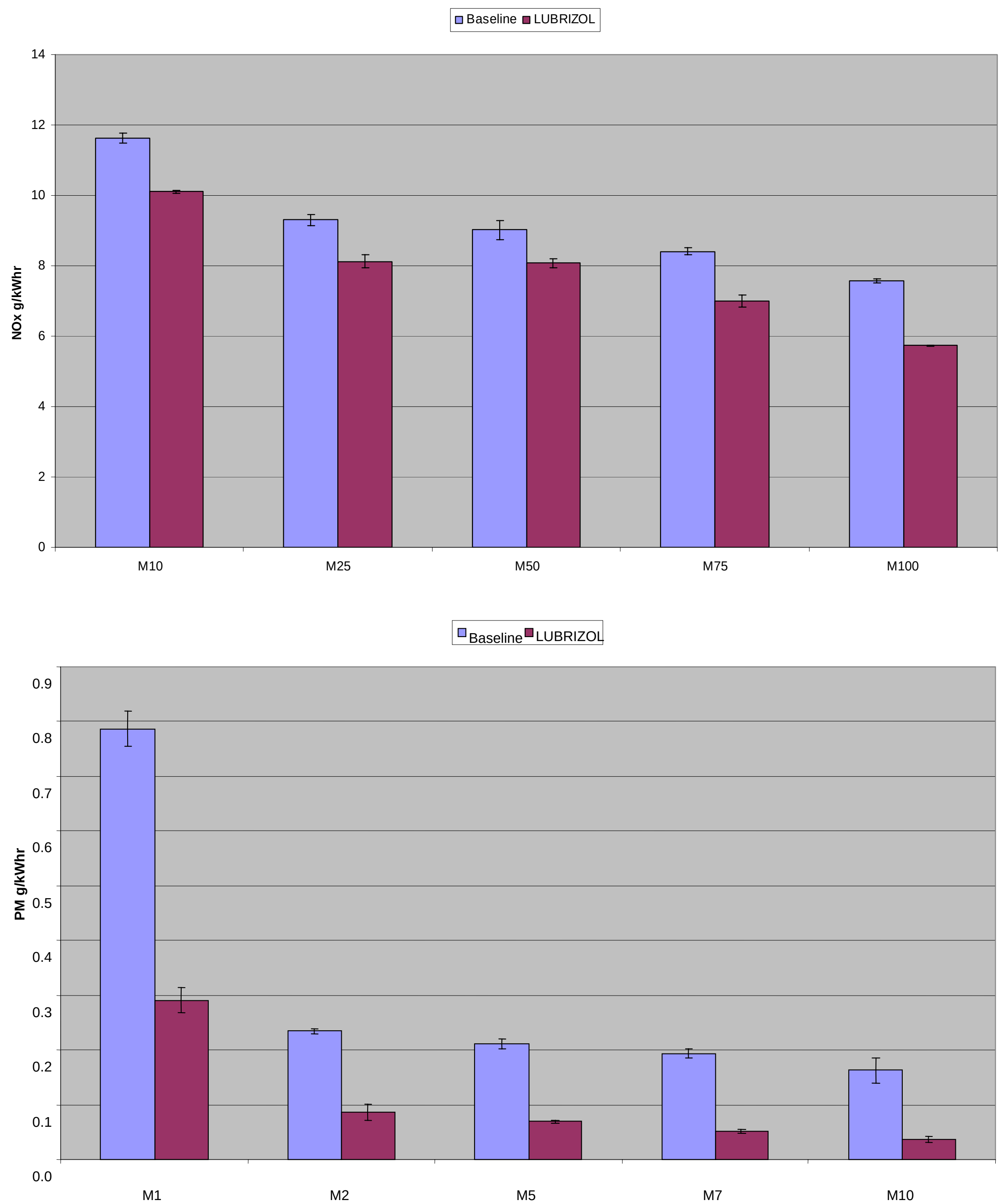


Figure 5-4. BUG #9 NO_X (top) and particulate (bottom) emissions comparison, baseline vs. water emulsion fuel[18]

---

18. M10–M100 refer to the operating load on the BUG. M10 refers to 10% load, whereas, M100 refers to 100% load. More information on test results will be available in a subsequent report concerning BUG emission testing.

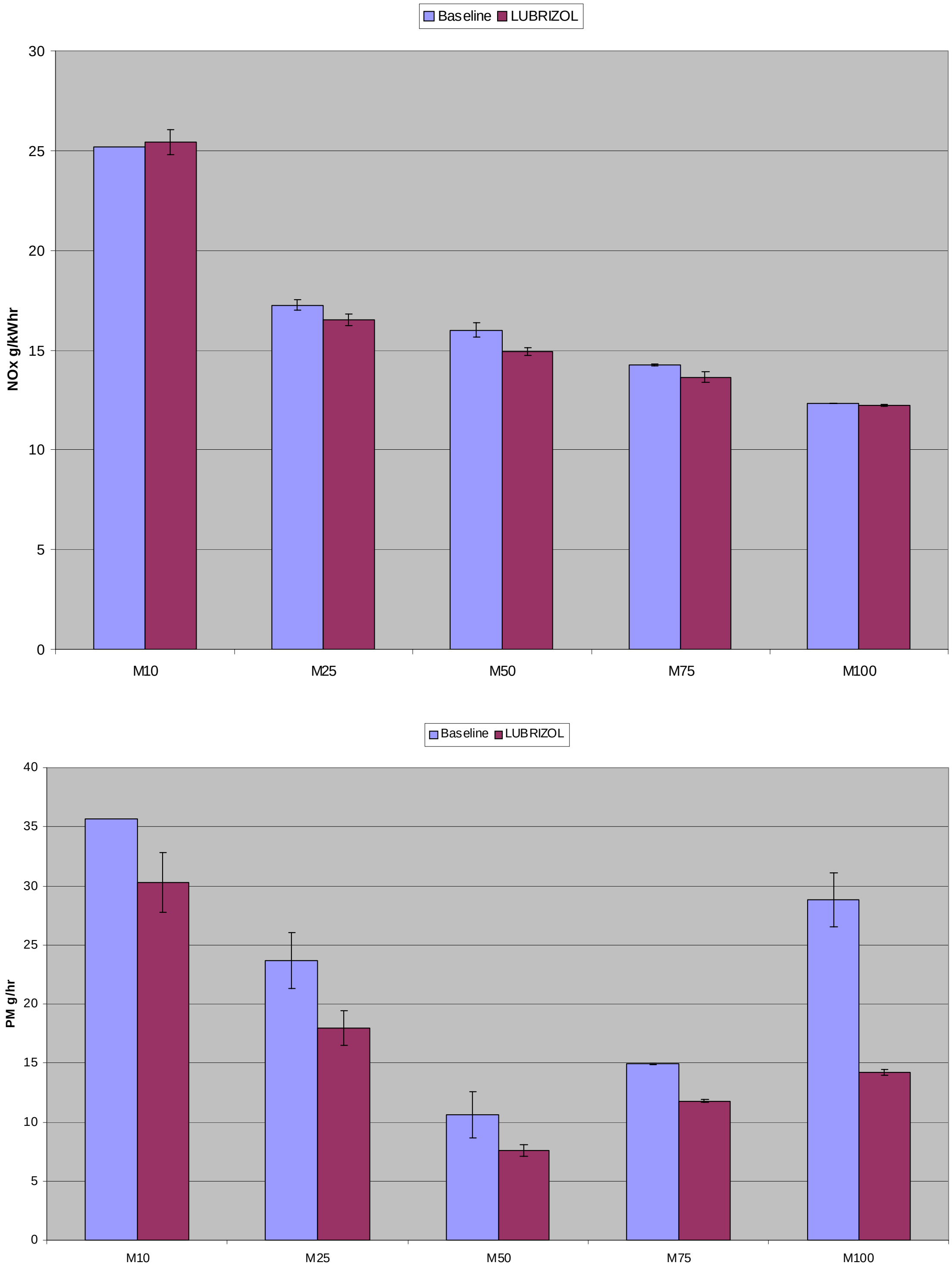


Figure 5-5. BUG #11 NO_X (top) and particulate (bottom) emissions comparison, baseline vs. water emulsion fuel[19]

---

19. See footnote 17.

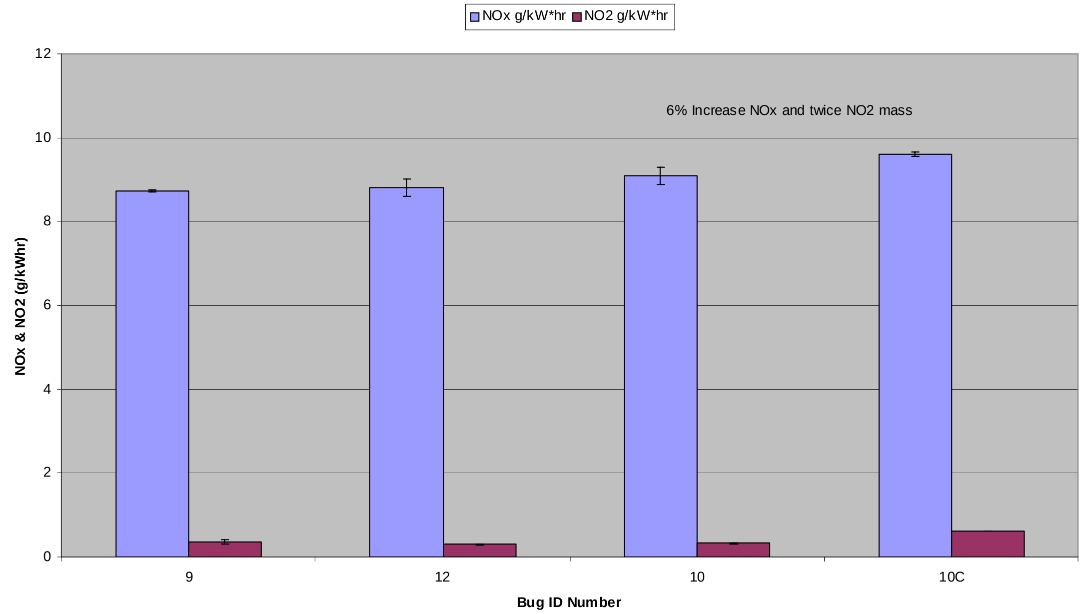


Figure 5-6. NO_X emissions from several BUGs before and after (labeled with "C") diesel oxidation catalyst retrofit[20]

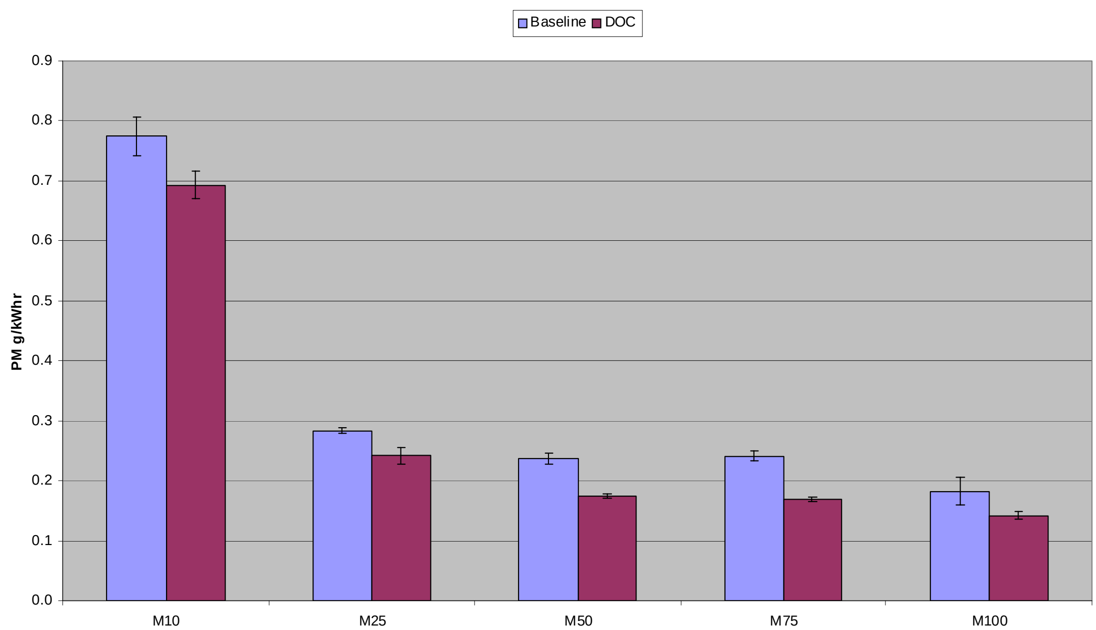


Figure 5-7. Average $PM_{2.5}$ Emissions from several BUGs before and after diesel oxidation catalyst retrofit[21]

20. See footnote 17.
21. See footnote 17.

6.0 Conclusions, Recommendations, and Benefits to California

Key results from the modeling portion of this project include the following:

- Emissions from BUGs during the May 8, 2001, outage were estimated to be 14.88 tons of nitrogen oxides (NO_X), 0.34 tons of sulfur dioxide (SO_2), 0.38 tons of particulate matter (PM_{10}), 1,246 tons of carbon dioxide (CO_2), 2.56 tons of carbon monoxide (CO), and 0.07 tons of volatile organic compounds (VOC).
- Modeling of exposure to particulate matter as a result of hypothetical BUGs operation found that all scenarios for both large and medium BUGs produce maximum cancer risks greater than 10 in a million—a common regulatory limit for permitting decisions.
- Analysis of the air quality model simulations and federal census data showed that the non-white population is 13% higher in block groups surrounding BUGs as compared to the State as a whole. Gender distribution is approximately the same; however, there is a 25% decrease in those under 18 years old and a 15% increase in those over 65 years old in block groups surrounding BUGs, as compared to the State as a whole.
- Direct mortality from exposure to $PM_{2.5}$ from BUGs was not estimated because of the lack of consensus on estimates of the direct mortality risk associated with $PM_{2.5}$. However, based on the review of Lloyd and Cackette (2001) and results of Environmental Defense (2002), it is possible that direct mortality risks could be a significant concern.

Air quality modeling for ozone (O_3) indicates that NO_X emissions from BUGs can have a substantial impact on air quality, with reductions in O_3 near the BUGs source but increases in O_3 further downwind. Ozone levels decreased by 10 parts per billion (ppb) or more near the source because of NO titration of O_3 and NO_2 scavenging of hydroxyl free radicals, but O_3 levels increased downwind because the transported NO_X caused greater O_3 production.

7.0 References

Byun, D. W., and J. K. S. Ching. 1999. "Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System," EPA/600/R-99/030.

Chang, J. S., S. Jin, Y. Li, M. Beauharnois, C. H. Lu, H. C. Huang, S. Tanrikulu, and J. DaMassa. 1997. The SARMAP Air Quality Model, Final Report. Prepared for the San Joaquin Valleywide Air Pollution Study Agency.

Damassa, J., S. Tanrikulu, A. J. Ranzieri, L. Niccum. 1996. Performance Evaluation of the SAQM in Central California and Attainment Demonstration for the August 3–6, 1990 Ozone Episode. Modeling and Support Section, Technical Support Division, California Air Resources Board. February.

ENVIRON. 2002. "User's Guide Comprehensive Air Quality Model With Extensions (CAMx) Version 3.10." ENVIRON International Corporation, Novato, California (available at www.camx.com). April.

Field, M., and C. P. Sooner. 1999. *California Government and Politics Today*, 8th edition. New York: Longman.

Harris, R. A., and S. Milks. 1996. *The Politics of Regulatory Change: A Tale of Two Agencies*. New York: Oxford University Press.

Keck, M. E., and K. Skink. 1998. *Activists Beyond Borders: Advocacy Networks in International Politics*. Ithaca: Cornell University Press.

Jana, K., J. M. Berry, and J. Goldman. 1990. *The Challenge of Democracy: Government in America*. Boston: Houghton Mifflin Company.

Lawrence, D. G. 1999. *California: The Politics of Diversity*. Toronto: Wadsworth.

Little, A. D. 2001. *Inventory of Backup Generators in the State of California.* December 2001. www.energy.ca.gov/reports/2002-02-15_500-01-027.PDF.

Lloyd, A. C., and T. A. Cackette. 2001. Diesel Engines: Environmental Impact and Control. *J. Air and Waste Management Assoc.* 51: 809–847.

Marko, L., and K. Radisson. 2002. Utilitarianism and Fairness as Two Different Families of Motives for Cooperation. Typescript.

Moraine, D. 2001. "Davis Eases Power Plant Pollution Rules," *Los Angeles Times*, 12 June.

Richter, B. 2001. "The Key: Reduce Demand." *Los Angeles Times*, 20 May.

Ryan, N. E., K. M. Larsen, P. C. Black. 2002. *Smaller, Closer, Dirtier: Diesel Backup Generators in California*. Environmental Defense. 2002.

Sideman, H. 1998. *Politics, Position, and Power: The Dynamics of Federal Organization*. New York: Oxford University Press.

Wagner, P. 1996. *Environmental Activism and World Civic Politics*. Albany: State University of New York Press.

West, J., and G. Busman. 1999. Implementation of Environmental Policy: The Chief Executive. In *The Environmental Presidency*, Dennis L. Soden, ed. Albany: SUNY Press. 77–111.

8.0 Glossary

APCD	air pollution control district
AQMD	air quality management district
BACT	best available control technology
BUGs	backup generators
CAA	Clean Air Act
CalEPA	California Environmental Protection Agency
Cal-ISO/ISO	California Independent Service Operator
CAMx	Comprehensive Air Quality Model with extensions
CAPCOA	California Air Pollution Control Officer's Association
CARB	California Air Resources Board
CCOS	Central California Ozone Study
CDWR	California Department of Water Resources
CE-CERT	Bourns College of Engineering-Center for Environmental Research and Technology
CHP	combined heat and power
CMAQ	Community Multiscale Air Quality model
DOE	U. S. Department of Energy
DG	distributed generation
EO	Executive order
FIP	federal implementation plan
GIS	geographical information system
GMT	Greenwhich mean time
HI	hazard index

ISC	industrial source complex
ISCST3	Industrial Source Complex Short Term Dispersion Model
MM5	Mesoscale Model Version 5 (MM5)
NAAQS	National Ambient Air Quality Standards
OBMC	optional binding mandatory curtailment
PG&E	Pacific Gas & Electric
PSD	prevention of significant deterioration
REL	reference exposure level
SAQM	SARMAP Air Quality Model
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SCOS	Southern California Ozone Study
SDGE	San Diego Gas & Electric
SIP	state implementation plan
SMOKE	sparse matrix operator kernel
TIP	Tribal Implementation Plan
UAM	Urban Airshed Model
UC	University of California
UCR	University of California, Riverside
U.S. EPA/EPA	United States Environmental Protection Agency
WRAP	Western Regional Air Partnership

Appendix A

Determination of Emission Factors from Backup Generators

It is important to correctly identify emission rates from backup generators throughout California to properly assess emissions and health impacts of their operation. Historically, there has been a very limited database of emissions measurements from diesel generators. The main sources of information include the EPA's Compilation of Emission Factors (EPA 1993, 1996) and the recent report by Bluestein. These data sets have a wide range of values and uncertainty, and are only from a very limited sample set (Table 1).

Table 1. Range of Emissions from diesel generators in current literature

Pollutant	Low Range (lb/MWh)	High Range (lb/MWh)
NO_X	5.9	17.1
PM	0.74	3
CO_2	1482	1700
CO	7.6	30
VOC	0.73	2
SO_2	0.3	0.5

As part of this study, a variety of in-use backup generators (BUGs) were located and tested in the field to determine their emissions (CE-CERT in progress). Results from 5 BUGs and 28 tests were used to develop the emission rates used in this analysis. Table 2 lists the BUGs tested to date in this program. Testing of additional BUGs are underway.

Table 2. BUGs used to develop emission rate estimates

Location	Make	Model	VIN/Serial #	Generator Type	Max Power kW
Johnson Mach	CAT 3412C	3412 C	BPG00177	Primary	545
VAFB	CAT 3406C	3406 C	4RG01632	Backup	300
VAFB	DETROIT 92	80837405	BVF149700	Backup	350
SB University	CAT 3406C	3406 C	4JK00753	Primary	350
Johnson 340xx 350	CAT 3406	3406 C	4JK00706	Primary	350

Emissions were observed as a function of BUG model, size, operating load, and measurement method to determine the significant variables. All measurements were performed using reformulated diesel fuel (CARB 2000) and using the ISO 8178 and Method 5 methods. It was observed that the Detroit Diesel behaved significantly different than the other generators, and was placed in a separate category for 2-stroke engines. Other significant variables observed include the operating load and the measurement method. The size and make (other than the 2-stroke model) of the generator did not show an effect on emissions. Therefore, emission rates were developed for 2 and 4 strokes as a function of operating mode and for each measurement method. Figures 1 and 2 show particulate matter emissions for each measurement method. Method 5 test results are approximately three times higher than the ISO 8178 method.

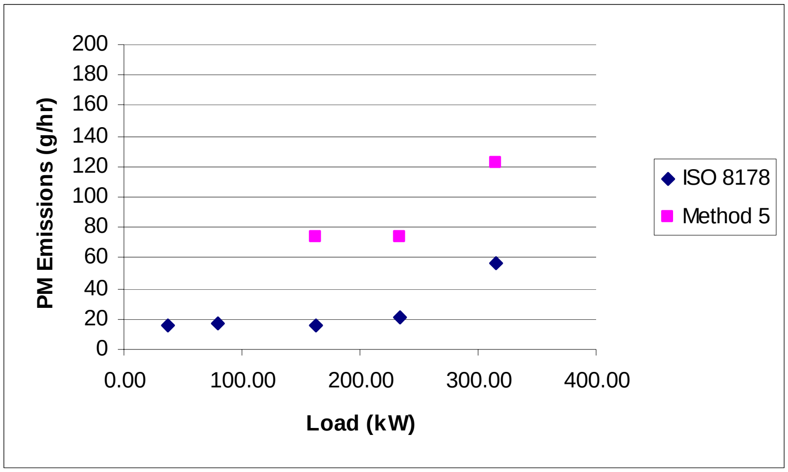


Figure 1. Measurement method comparison for 4-stroke diesel generators

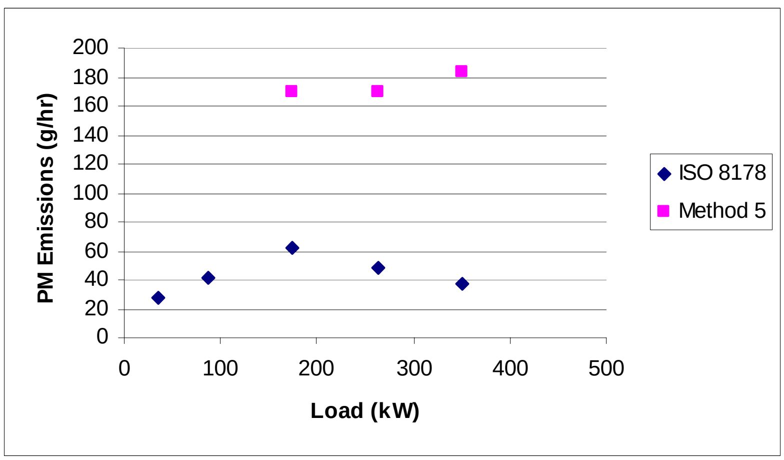


Figure 2. Measurement method comparison for 2-stroke diesel generators

The emissions used in this report were limited to the values using the approved ISO 8178 method for 4 strokes only, since the vast majority of the BUGs in the inventory are 4 strokes. Figures 3—7 show the emissions results of the five BUGs tested as a function of load on the generator for the ISO 8178 testing method. The best fit for all pollutants was determined to be in the form of a linear equation (Eq 1). The coefficients and equations are shown in each figure in bold font for 4 strokes and in normal font for 2-stroke generators. The equations were used to extrapolate the emissions to operating loads greater than 550 kW, where there have not been any CE-CERT tests conducted. Under normal circumstances, it would not be appropriate to use these equations outside of the range of the test data. However, these equations were validated with some proprietary data available to the authors, and therefore it is in the author's viewpoint that these equations should reasonably represent BUGs emissions up to a 2000-kW load.

$$\text{Emission Rate (g/hr)} = b*x + c \qquad \text{(Eq. 1)}$$

where x = operating load in kW
b, c = constants for each pollutant

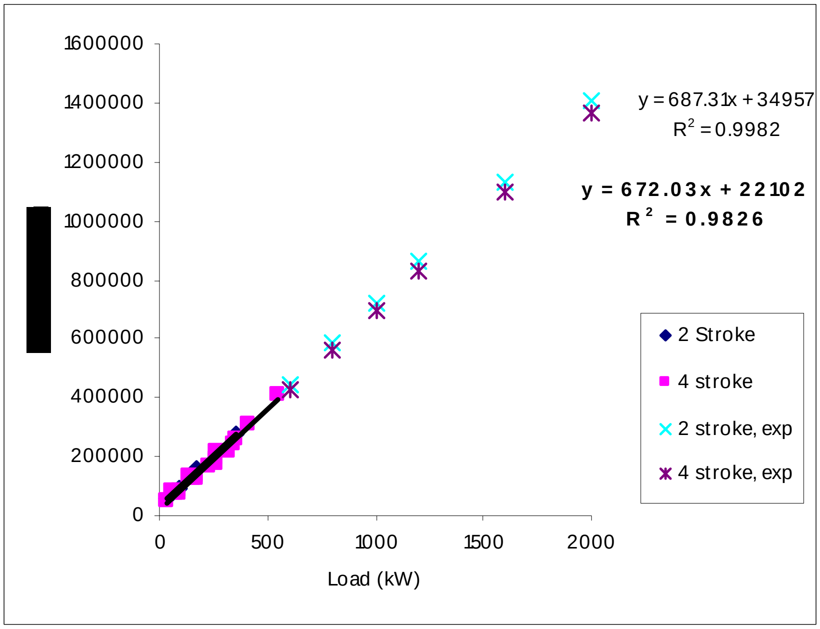


Figure 3. CO_2 Emissions for diesel generators (ISO 8178)

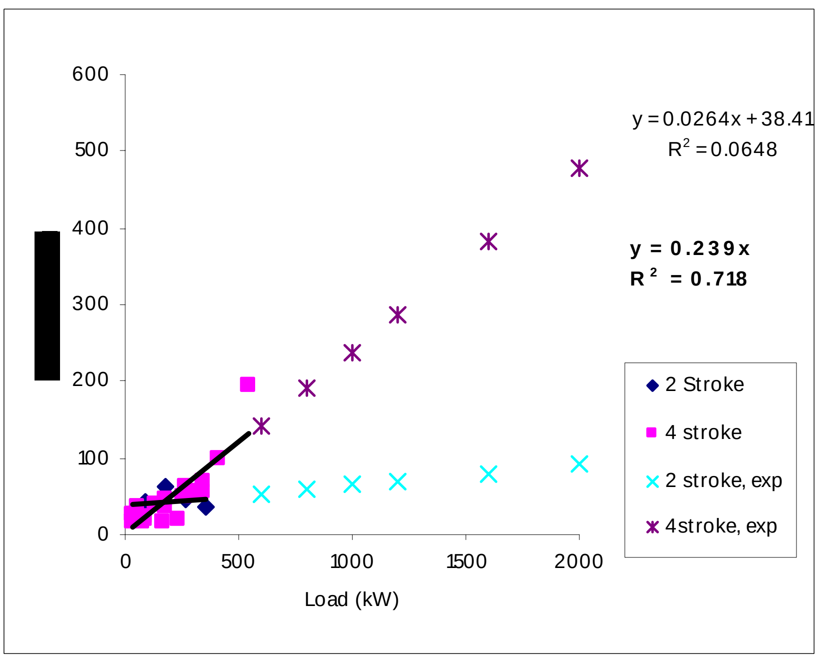


Figure 4. Total PM emissions for diesel generators (ISO 8178)

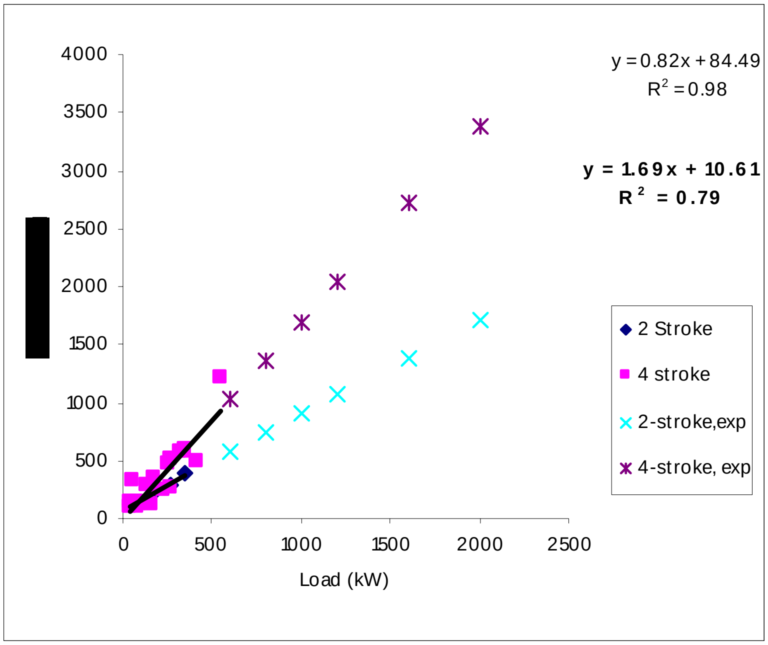


Figure 5. CO emissions for diesel generators (ISO 8178)

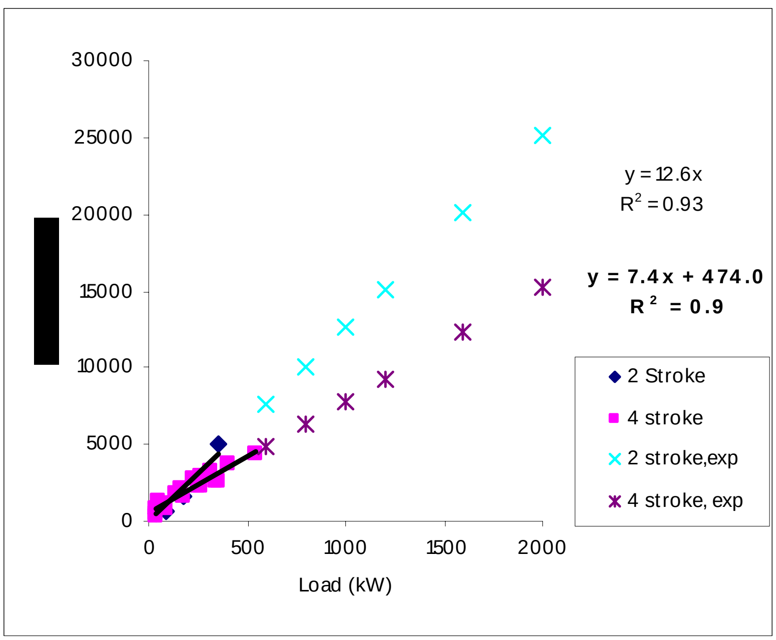


Figure 6. NO_X emissions from diesel generators (ISO 8178)

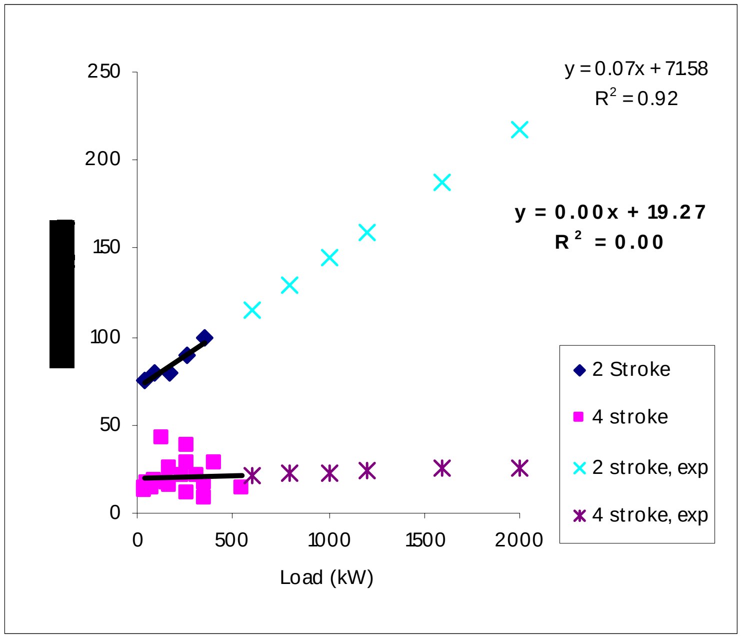


Figure 7. VOC emissions from diesel generators (ISO 8178)

Table 3 summarizes the emissions in pounds per megawatt-hour (lb/MWh) from 4-stroke diesel generators. These emission rates were used in the air quality modeling. The italicized blue values indicate emissions were estimated outside of the testing range. Because SO_2 emissions were not measured in the CE-CERT tests, SO_2 emissions from Table 1 were used in the air quality analysis.

Table 3. Summary of emissions from 4-stroke diesel generators (ISO 8178)

Load	VOC	THC	CH_4	CO	NO_X	CO_2	PM
kW	lb/MWh	lb/MWh	lb/MWh	lb/MWh	lb/MWh	lb/MWh	lb/MWh
100	0.463	0.546	0.088	4.51	26.54	2003.01	0.457
200	0.249	0.282	0.062	3.70	21.64	1715.34	0.457
300	0.177	0.193	0.053	3.43	20.00	1619.45	0.457
400	0.142	0.149	0.049	3.29	19.19	1571.50	0.457
500	0.120	0.123	0.046	3.21	18.70	1542.74	0.457
600	*0.106*	*0.105*	*0.044*	*3.16*	*18.37*	*1523.56*	*0.457*
800	*0.088*	*0.083*	*0.042*	*3.09*	*17.96*	*1499.59*	*0.457*
1000	*0.077*	*0.070*	*0.041*	*3.05*	*17.72*	*1485.20*	*0.457*
1200	*0.070*	*0.061*	*0.040*	*3.02*	*17.55*	*1475.61*	*0.457*
1600	*0.061*	*0.050*	*0.039*	*2.99*	*17.35*	*1463.63*	*0.457*
2000	*0.056*	*0.043*	*0.038*	*2.97*	*17.23*	*1456.44*	*0.457*

References

Bluestein, Joel. "Environmental Benefits of Distributed Generation" Energy and Environmental Analysis, Inc. Draft, December 2000 www.raponline.org/ProjDocs/DREmsRul/Comments/DGEmissions-Bluestein.pdf?]

California Air Resources Board. 2000. California Diesel Fuel. Fact Sheet. www.arb.ca.gov/fuels/diesel/dieselfs.pdf

CE-CERT. *Measurement of Emissions from Back-Up Generators.* DRAFT Report in Progress.

U. S. Environmental Protection Agency (EPA). 1993. *Compilation of Emission Factors, AP-42.* Volume 1, 5th Edition, Section 3.4 Large Stationary Diesel and All Stationary Dual Fuel Engines."

U. S. Environmental Protection Agency (EPA). 1996. *Compilation of Emission Factors, AP-42.* Volume 1, 5th Edition, Section 3.3 Gasoline and Diesel Industrial Engines, Supplement B. October.

Appendix B

Spatial Coordinates of BUGs Operated on May 8, 2001

Table 2.1 lists the BUGs and their spatial coordinates that were operated by customers on “firm” electrical service contracts. Table 2.2 lists the BUGs and their spatial coordinates that were operated by customers on “non-firm” electrical service contracts.

Table 2.1. Spatial coordinates of BUGs operated by “firm” customers

BUGs Operated by Firm Customers. 615 kW for 4.9 Hours Each.			
Facility Name	**Facility Street Address**	**Latitude**	**Longitude**
KAISER FOUNDATION HOSPITAL (ANAHEIM)	441 N LAKEVIEW AVE, Anaheim, 92807	33.8533	-117.8160
ASSOCIATES INFORMATION SERVICES, INC	17770 CARTWRIGHT RD, Irvine, 92614	33.6827	-117.8450
ASSOCIATES INFORMATION SERVICES, INC	17770 CARTWRIGHT RD, Irvine, 92614	33.6827	-117.8450
INTELENET COMMUNICATIONS	17222 VON KARMAN, Irvine, 92614	33.6910	-117.8410
IRVINE RANCH WATER DIST	VARIOUS LOCATIONS, Irvine, 92619	33.6550	-117.7370
IRVINE RANCH WATER DIST	VARIOUS LOCATIONS, Irvine, 92619	33.6550	-117.7370
IRVINE RANCH WATER DIST	3512 MICHELSON DR, Irvine, 92612	33.6705	-117.8350
IRVINE RANCH WATER DIST	VARIOUS LOCATIONS, Irvine, 92619	33.6550	-117.7370
IRVINE RANCH WATER DIST	VARIOUS LOCATIONS, Irvine, 92619	33.6550	-117.7370
IRVINE RANCH WATER DIST	VARIOUS LOCATIONS, Irvine, 92619	33.6550	-117.7370
F-D-S MANUFACTURING CO INC	2200 S RESERVOIR ST, Pomona, 91766	34.0318	-117.7320
DOUGLAS, EMMETT REALTY FUND - 1995 FFS	401 WILSHIRE BLVD, Santa Monica, 90401	34.0193	-118.4980
JACKSON NATIONAL LIFE DISTRIBUTERS INC	401 WILSHIRE BLVD, Santa Monica, 90401	34.0194	-118.4970
VERIZON CALIFORNIA INC	234 W FOOTHILL BLVD, Upland, 91786	34.1064	-117.6540

Table 2.1. Spatial coordinates of BUGs operated by "firm" customers (cont.)

BUGs Operated by Firm Customers. 615 kW for 4.9 Hours Each.			
Facility Name	**Facility Street Address**	**Latitude**	**Longitude**
VERIZON CALIFORNIA INC	234 W FOOTHILL BLVD, Upland, 91786	34.1064	-117.6530
WATER FACILITIES AUTHORITY - JPA	VARIOUS LOCATIONS IN SCAQMD, Upland, 91784	34.1378	-117.6580
TRUST CO OF THE WEST/A I M/CAL STRS	9595 WILSHIRE BLVD #407, Beverly Hills, 90212	34.0672	-118.4020
PRIME ENERGY SYSTEMS STORE #344	VARIOUS LOCATIONS IN SCAQMD, Fullerton, 92831	33.8888	-117.9240
VERIZON-REDONDO BEACH C.O.	102 PACIFIC COAST HWY, Hermosa Beach, 90254	33.8644	-118.3920
PACIFIC BELL	4918 IRVINE CENTER DR, Irvine, 92714	33.6849	-117.7860
PACIFIC BELL TELEPHONE CO	2350 S MAIN ST., Irvine, 92714	33.6843	-117.8490
PACIFIC BELL TELEPHONE CO	2350 S MAIN ST., Irvine, 92714	33.6843	-117.8490
RMS FOUNDATION INC	1256 S PIER J AVE., Long Beach, 90801	33.8604	-118.1510
DOHENY EYE INSTITUTE	1537 NORFOLK ST., Los Angeles, 90033	34.0616	-118.2030
WEST COAST LIQUIDATORS INC, PIC 'N' SAVE	12434 4TH ST., Rancho Cucamonga, 91730	34.0773	-117.5340
EMPIRE POWER SYSTEMS/JOHNSON POWER SYSTE	VARIOUS LOCATIONS, Riverside, 92502	33.9949	-117.3730
VERIZON CALIFORNIA INC	665 N E ST., San Bernardino, 92410	34.1115	-117.2940
ORANGE CO, PFRD/FACILITIES OPERATIONS	300320 FLOWER ST., Santa Ana, 92703	33.8054	-117.9930
ST. FRANCIS MEDICAL CENTER	601 E MICHELTORENA ST., Santa Barbara, 93103	34.4326	-119.7020

Table 2.1. Spatial coordinates of BUGs operated by "firm" customers (cont.)

BUGs Operated by Firm Customers. 615 kW for 4.9 Hours Each.			
Facility Name	**Facility Street Address**	**Latitude**	**Longitude**
AGGREKO INC	VARIOUS LOCATIONS IN SCAQMD, Santa Fe Springs, 90670-4995	33.9321	-118.0610
AGGREKO INC	VARIOUS LOCATIONS IN SCAQMD, Santa Fe Springs, 90670-4995	33.9321	-118.0610
TOOLEY & CO.	1299 OCEAN AVE., Santa Monica, 90401	34.0155	-118.5000
PACIFIC BELL	1125 9TH AV, San Diego, 92101	32.7170	-117.1560
DURA PHARMACEUTICALS	7475 LUSK BL, San Diego, 92121	32.8989	-117.2170
WILLIAMS COMMUNICATIONS INC	8923 COMPLEX DR, San Diego, 92123	32.8299	-117.1360
SONY ELECTRONICS INC.	16450 BERNARDO DR. W., San Diego, 92127	33.0128	-117.0900
PACIFIC BELL	2175 CAMINO VIDA ROBLE, Carlsbad, 92008	33.1177	-117.2770
PACIFIC BELL	146 BROADWAY S, Escondido, 92025	33.1213	-117.0810
No Name	793 Rincon Ave., Livermore, 94550	37.6017	-121.6600
No Name	793 Rincon Ave., Livermore, 94550	37.6017	-121.6600
No Name	793 Rincon Ave., Livermore, 94550	37.6017	-121.6600
SPRINT COMMUNICATIONS CO., L.L.P.	2405 Bird Street, Oroville, 95965	39.5153	-121.5490
No Name	3466 La Mesa Dr., Hayward, 94544	37.6065	-122.0530
No Name	2975 Treat Blvd., Concord, 94520	37.9708	-122.0480
SBC COMMUNICATIONS	2970 Bedford Ave., Placerville, 95667	38.7320	-120.7980
AT&T BROADBAND	2096 N. Gateway, Fresno, 93727	36.7699	-119.7230

Table 2.1. Spatial coordinates of BUGs operated by "firm" customers (cont.)

BUGs Operated by Firm Customers. 615 kW for 4.9 Hours Each.			
Facility Name	**Facility Street Address**	**Latitude**	**Longitude**
AT&T BROADBAND	1945 N. Helm Ave., Fresno, 93727	36.7681	-119.7230
PACIFIC BELL	525 E. Shaw, Clovis, 91910	32.6422	-117.0910
PACIFIC BELL	5555 E. Olive Ave., Fresno, 93727	36.7575	-119.7020
CAL DEPT OF CORRECTIONS WASCO	701 Scofield Rd., Wasco, 93280-8800	35.7174	-119.4010
FEDERAL PRISON @ TAFT	1500 Cadet Rd., Taft, 93268	35.1010	-119.3790
LEVEL 3 COMMUNICATIONS LLC	11090 10 1/2 Ave., Hanford, 93230	36.3074	-119.6460
PACIFIC BELL	221 S. E St., Madera, 93637	36.9607	-120.0580
AT&T Jamesburg Earth Station	37300 Comsat Rd., Carmel Valley, 93924	36.3942	-121.6370
AT&T Jamesburg Earth Station	37300 Comsat Rd., Carmel Valley, 93924	36.3942	-121.6370
MCI Worldcom	514 Salinas Rd., Watsonville, 95076	36.8945	-121.7480
Hewlett Packard	8000 Foothills Blvd., Roseville, 95747-5609	38.7661	-121.3910
No Name	No Address, 94103	37.7839	-122.4070
No Name	No Address, 94109	37.7895	-122.4160
No Name	No Address, 94115	37.7847	-122.4370
No Name	No Address, 94105	37.7887	-122.3920
No Name	No Address, 94111	37.7945	-122.3990
AT&T BROADBAND	844 E. Hammertown Lane, Stockton, 95210	38.0160	-121.3010
GTE OF CALIFORNIA	430 W. Center St., Manteca, 95336	37.7992	-121.2210
MCI INTERNATIONAL	2500 W. Turner Rd., Lodi, 95242	38.1456	-121.3150
WORLD COM	101 Los Olivos Ave., Los Osos, 93402	35.3132	-120.8330
CSU MONTEREY BAY	6th Ave. & B St., Seaside, 95060	37.0663	-122.1920

Table 2.1. Spatial coordinates of BUGs operated by "firm" customers (cont.)

BUGs Operated by Firm Customers. 615 kW for 4.9 Hours Each.			
Facility Name	**Facility Street Address**	**Latitude**	**Longitude**
No Name	No Address, 95112	37.3430	-121.8760
No Name	No Address, 95112	37.3430	-121.8760
No Name	No Address, 95124	37.2536	-121.9510
No Name	No Address, 95124	37.2536	-121.9510
SILICON SYSTEMS, INC. (TEXAS INSTRUMENTS)	2300 Delaware Ave., Santa Cruz, 95060	36.9544	-122.0600
SILICON SYSTEMS, INC. (TEXAS INSTRUMENTS)	2300 Delaware Ave., Santa Cruz, 95060	36.9544	-122.0600
WILLIAMS COMMUNICATIONS	1224 13th St., Modesto, 95354	37.6468	-121.0030
VERIZON CALIFORNIA, INC.	1810 Parnell Ave., Westwood, 93167	40.2879	-121.0990
U.S. FISH & WILDLIFE SERVICE	24411 Coleman Hatchery Road, Anderson, 96007	40.4519	-122.2960

Table 2.2. Spatial coordinates of BUGs operated by interruptible-service customers

Facility Name	Facility Street Address	Latitude	Longitude
COACHELLA VALLY DEV	1333 S BELARDO RD CHS, PALM SPRINGS, 92264	33.814	-116.548
COACHELLA VALLY DEV	1333 S BELARDO RD CHS, PALM SPRINGS, 92264	33.814	-116.548
COACHELLA VALLY DEV	1333 S BELARDO RD CHS, PALM SPRINGS, 92264	33.814	-116.548
DIPLOMAT OWNER ASSN	1630 S LA REINA WAY #HM, PALM SPRINGS, 92264	33.803	-116.522
DIPLOMAT OWNER ASSN	1630 S LA REINA WAY #HM, PALM SPRINGS, 92264	33.803	-116.522
M & R PARTNERSHIP	4190 E PALM CANYON DR 100, PALM SPRINGS, 92264	33.795	-116.502
M & R PARTNERSHIP	4190 E PALM CANYON DR 100, PALM SPRINGS, 92264	33.795	-116.502
M & R PARTNERSHIP	4190 E PALM CANYON DR 100, PALM SPRINGS, 92264	33.795	-116.502
DECRATREND CORP	1227 S GENE AUTRY TRL A, PALM SPRINGS, 92264	33.807	-116.493
DECRATREND CORP	1227 S GENE AUTRY TRL A, PALM SPRINGS, 92264	33.807	-116.493
C-VISA, INC	934 S VELLA RD, PALM SPRINGS, 92264	33.809	-116.497
C-VISA, INC	934 S VELLA RD, PALM SPRINGS, 92264	33.809	-116.497
LONG BEACH, CITY OF WATER DE	2950 REDONDO AVE , LONG BEACH, 90806	33.809	-118.151
LONG BEACH, CITY OF WATER DE	2950 REDONDO AVE , LONG BEACH, 90806	33.809	-118.151
LONG BEACH, CITY OF WATER DE	2950 REDONDO AVE , LONG BEACH, 90806	33.809	-118.151
VISTA PAINT CORP	3405 E ARTESIA BLVD, LONG BEACH 90805	33.975	-118.153
VISTA PAINT CORP	3405 E ARTESIA BLVD, LONG BEACH 90805	33.975	-118.153
VISTA PAINT CORP	3405 E ARTESIA BLVD, LONG BEACH 90805	33.975	-118.153
TIDELANDS OIL PRODUCTION CO	PIER J SITE J7, LONG BEACH, 90802	33.7387	-118.191
TIDELANDS OIL PRODUCTION CO	PIER J SITE J7, LONG BEACH, 90802	33.7387	-118.191
TIDELANDS OIL PRODUCTION CO	PIER J SITE J7, LONG BEACH, 90802	33.7387	-118.191
CALIFORNIA REFRIGERATED SERVCS	625 W ANAHEIM ST, LONG BEACH, 90813	33.783	-118.201
CALIFORNIA REFRIGERATED SERVCS	625 W ANAHEIM ST, LONG BEACH, 90813	33.783	-118.201

Table 2.2. Spatial coordinates of BUGs operated by interruptible-service customers (cont.)

Facility Name	Facility Street Address	Latitude	Longitude
COACHELLA VALLEY WATER DEPT	160 LAS LOMAS PMP, PALM DESERT, 92260	33.75	-116.391
COACHELLA VALLEY WATER DEPT	160 LAS LOMAS PMP, PALM DESERT, 92260	33.75	-116.391
GUTHY-RENKER CORP	41550 ECLECTIC ST 120, PALM DESERT, 92260	33.745	-116.358
GUTHY-RENKER CORP	41550 ECLECTIC ST 120, PALM DESERT, 92260	33.745	-116.358
JIM HARGATE TV INC	73091 COUNTRY CLUB DR A6, PALM DESERT, 92260	33.758	-116.39
JIM HARGATE TV INC	73091 COUNTRY CLUB DR A6, PALM DESERT, 92260	33.758	-116.39
AUTOMATED TELECOM INC	73700 HIGHWAY 111 8, PALM DESERT, 92260	33.723	-116.382
CHEESE & PROTEIN INTERNATIONAL	800 E PAIGE AVE, TULARE, 93274	36.182	-119.3306
CHEESE & PROTEIN INTERNATIONAL	800 E PAIGE AVE, TULARE, 93274	36.182	-119.3306
CHEESE & PROTEIN INTERNATIONAL	800 E PAIGE AVE, TULARE, 93274	36.182	-119.3306
MID VALLEY COTTON GROWERS INC	626 W CARTMILL AVE, TULARE, 93274	36.24	-119.357
MID VALLEY COTTON GROWERS INC	626 W CARTMILL AVE, TULARE, 93274	36.24	-119.357
TULARE CITY ELEM SCHOOL DIST	500 S LASPINA ST, TULARE, 93274	36.205	-119.322
TULARE CITY ELEM SCHOOL DIST	500 S LASPINA ST, TULARE, 93274	36.205	-119.322
IRVINE RANCH WATER DISTRICT	500 W ALTON AVE PMP, SANTA ANA, 92707	33.704	-117.875
IRVINE RANCH WATER DISTRICT	500 W ALTON AVE PMP, SANTA ANA, 92707	33.704	-117.875
IRVINE RANCH WATER DISTRICT	500 W ALTON AVE PMP, SANTA ANA, 92707	33.704	-117.875
ASTECH MCI MANUFACTURING INC	1900 E DEERE AVE, SANTA ANA, 92705	33.705	-117.85
ASTECH MCI MANUFACTURING INC	1900 E DEERE AVE, SANTA ANA, 92705	33.705	-117.85
ASTECH MCI MANUFACTURING INC	1900 E DEERE AVE, SANTA ANA, 92705	33.705	-117.85
IRVINE RANCH WATER DISTRICT	16003 1/2 CULVER, IRVINE, 92714	33.689	-117.805
IRVINE RANCH WATER DISTRICT	16003 1/2 CULVER, IRVINE, 92714	33.689	-117.805

Table 2.2. Spatial coordinates of BUGs operated by interruptible-service customers (cont.)

Facility Name	Facility Street Address	Latitude	Longitude
IRVINE RANCH WATER DISTRICT	16003 1/2 CULVER, IRVINE, 92714	33.689	-117.805
KAISER AEROSPACE & ELEC CORP	17000 RED HILL AVE, IRVINE, 92614	33.700	-117.849
KAISER AEROSPACE & ELEC CORP	17000 RED HILL AVE, IRVINE, 92614	33.700	-117.849
KAISER AEROSPACE & ELEC CORP	17000 RED HILL AVE, IRVINE, 92614	33.700	-117.849
VISALIA, CITY OF	336 N BEN MADDOX WAY, VISALIA, 93292	36.332	-119.278
VISALIA, CITY OF	336 N BEN MADDOX WAY, VISALIA, 93292	36.332	-119.278
VISALIA, CITY OF	336 N BEN MADDOX WAY, VISALIA, 93292	36.332	-119.278
PW EAGLE INC	8875 AVENUE 304, VISALIA, 93291	36.342	-119.342
PW EAGLE INC	8875 AVENUE 304, VISALIA, 93291	36.342	-119.342
PW EAGLE INC	8875 AVENUE 304, VISALIA, 93291	36.342	-119.342
SAN BERNARDINO, COUNTY OF	14360 ARROW BLVD, FONTANA, 92335	34.099	-117.492
SAN BERNARDINO, COUNTY OF	14360 ARROW BLVD, FONTANA, 92335	34.099	-117.492
SAN BERNARDINO, COUNTY OF	14360 ARROW BLVD, FONTANA, 92335	34.099	-117.492
CALIFORNIA STEEL INDUSTRIES	14000 SAN BERNARDINO, FONTANA, 92335	34.078	-117.5
CALIFORNIA STEEL INDUSTRIES	14000 SAN BERNARDINO, FONTANA, 92335	34.078	-117.5
SEALED AIR CORPORATION	19440 ARENTH AVE, LA PUENTE, 91748	33.999	-117.878
SEALED AIR CORPORATION	19440 ARENTH AVE, LA PUENTE, 91748	33.999	-117.878
SEALED AIR CORPORATION	19440 ARENTH AVE, LA PUENTE, 91748	33.999	-117.878
REULAND ELECTRIC CO#	17969 E RAILROAD, LA PUENTE, 91748	33.997	-117.912
REULAND ELECTRIC CO#	17969 E RAILROAD, LA PUENTE, 91748	33.997	-117.912
NEBEKER RANCH, INC	50400 55TH ST W, LANCASTER, 93534	34.799	-118.229
NEBEKER RANCH, INC	50400 55TH ST W, LANCASTER, 93534	34.799	-118.229

Table 2.2. Spatial coordinates of BUGs operated by interruptible-service customers (cont.)

Facility Name	Facility Street Address	Latitude	Longitude
NEBEKER RANCH, INC	50400 55TH ST W, LANCASTER, 93534	34.799	-118.229
CAMELOT ELECTRIC SUPPLY	43827 DIVISION ST, LANCASTER, 93535	34.68	-118.131
CAMELOT ELECTRIC SUPPLY	43827 DIVISION ST, LANCASTER, 93535	34.68	-118.131
SAN BERNARDINO, CITY OF	3150 WATERMAN, SAN BERNARDINO, 92401	34.148	-117.279

Appendix C

Local Dispersion and Population Exposure Scenarios

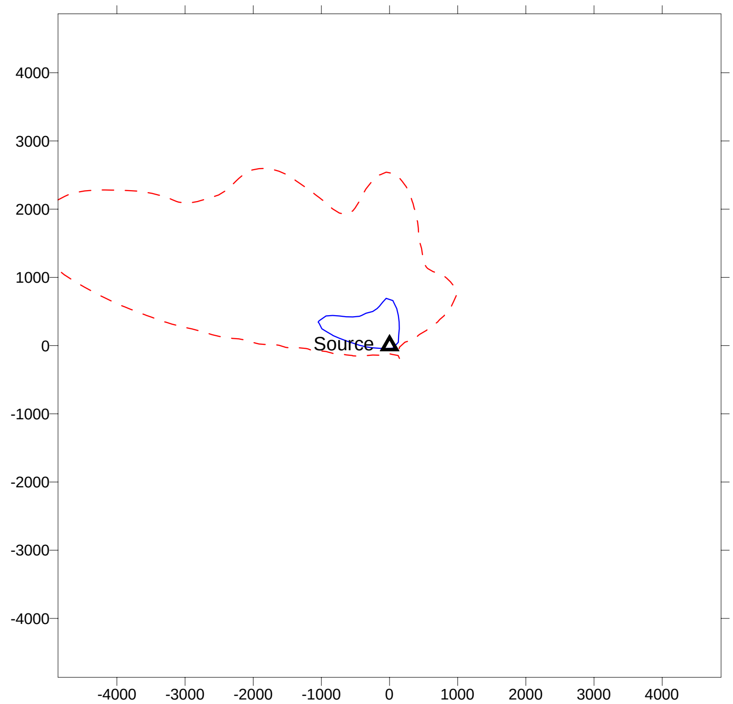


Figure 3.1. 10-in-a-million (blue line) and 1-in-a-million (red line) cancer risk isopleth from PM_{10}. Large BUG, downwash, rural, 8-hour, Burbank.

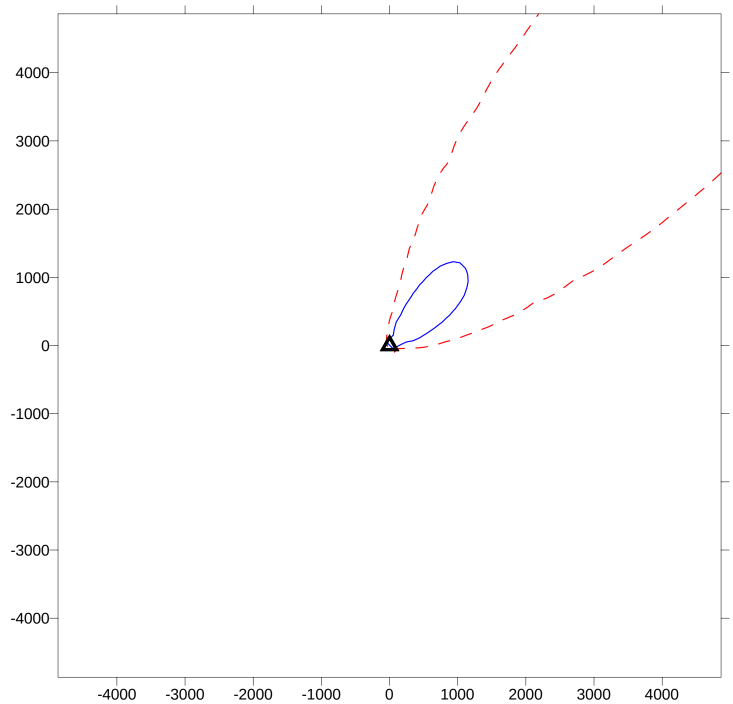


Figure 3.2. 10- and 1–in-a-million cancer risk isopleth Large, downwash, rural, 8-hour, West Los Angeles.

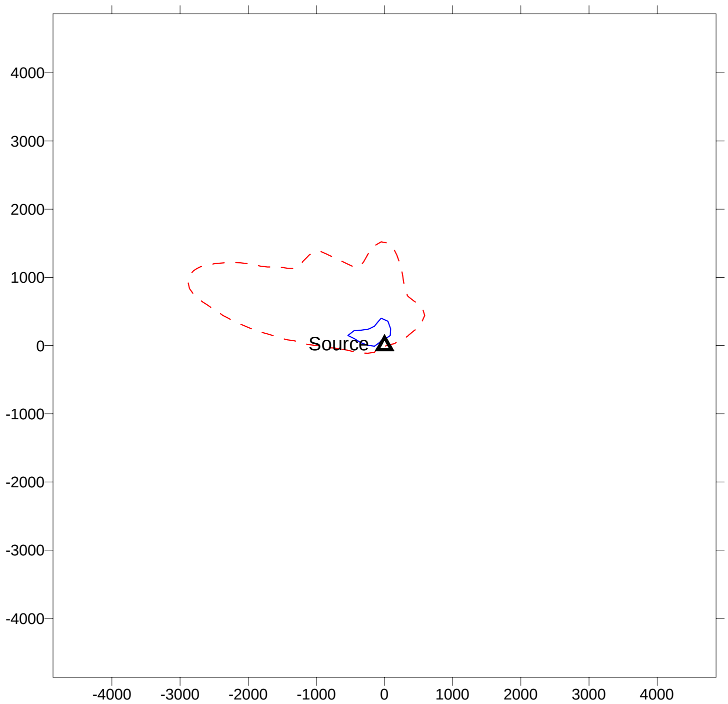


Figure 3.3. 10- and 1-in-a-million cancer risk isopleth. Large, no downwash, rural, 8-hour, Burbank.

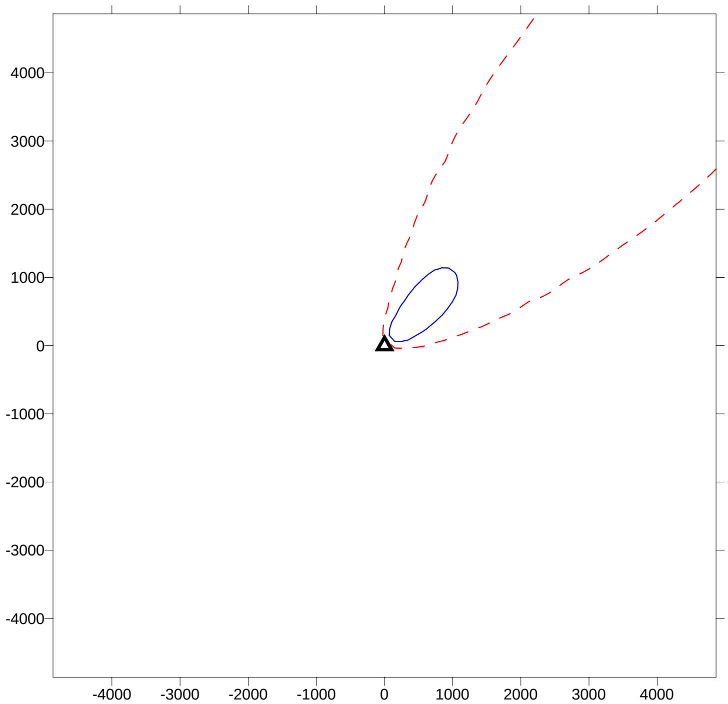


Figure 3.4. 10- and 1-in-a-million cancer risk isopleth. Large, no downwash, rural, 8-hour, West Los Angeles.

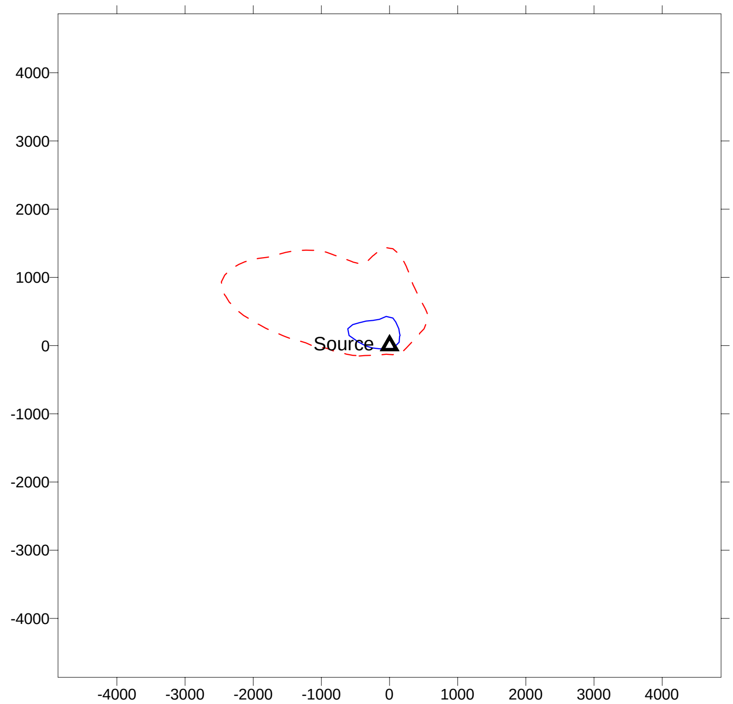


Figure 3.5. 10- and 1-in-a-million cancer risk isopleth. Large, downwash, urban, 8-hour, Burbank.

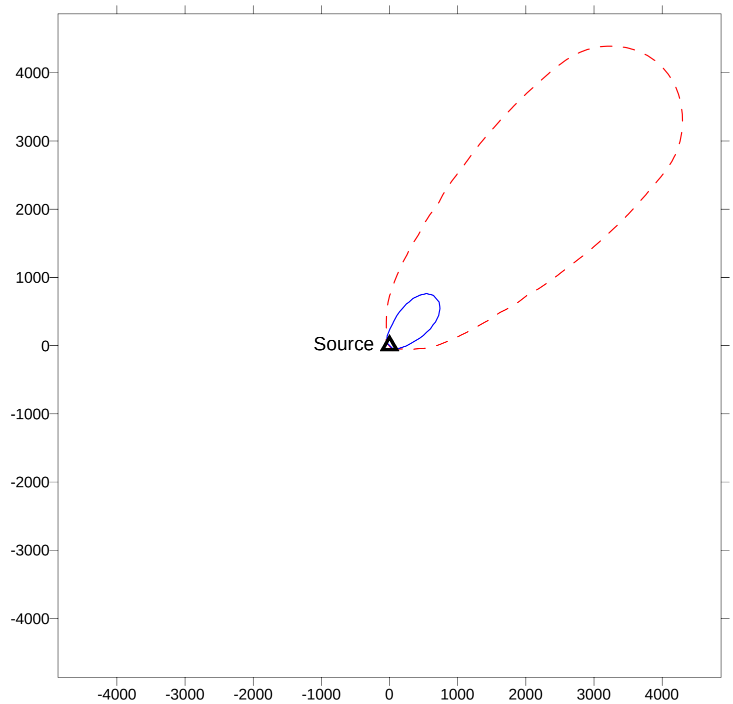


Figure 3.6. 10- and 1-in-a-million cancer risk isopleth. Large, downwash, urban, 8-hour, West Los Angeles.

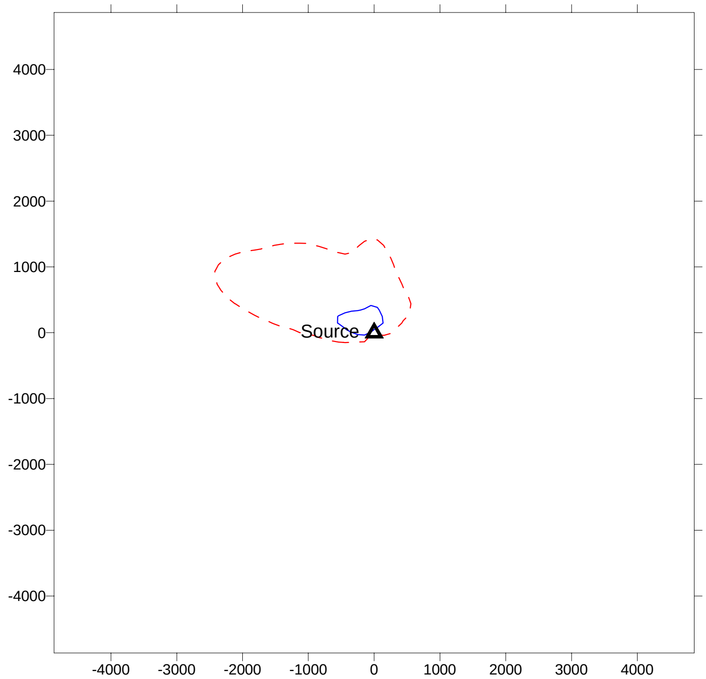


Figure 3.7. 10- and 1-in-a-million cancer risk isopleth. Large, no downwash, urban, 8-hour, Burbank.

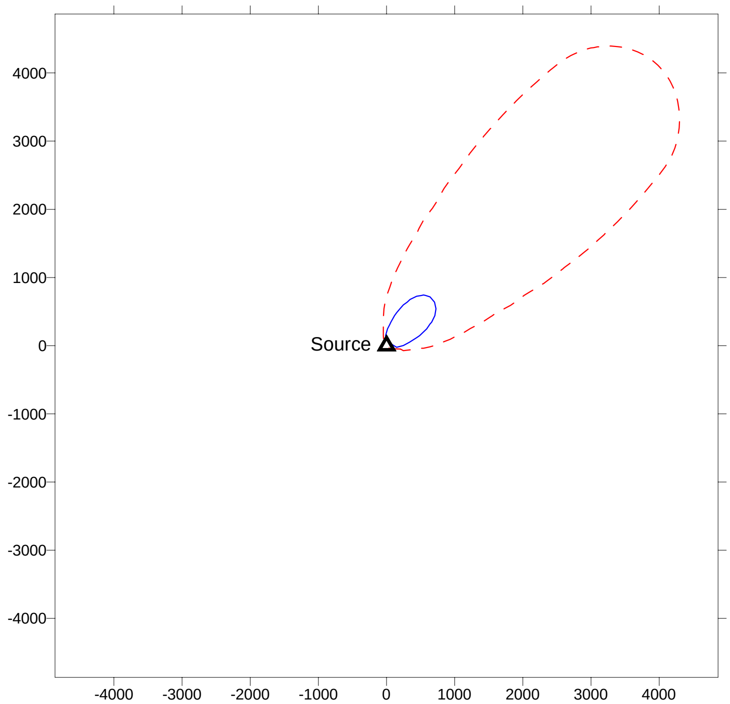


Figure 3.8. 10- and 1-in-a-million cancer risk isopleth. Large, no downwash, urban, 8-hour, West Los Angeles.

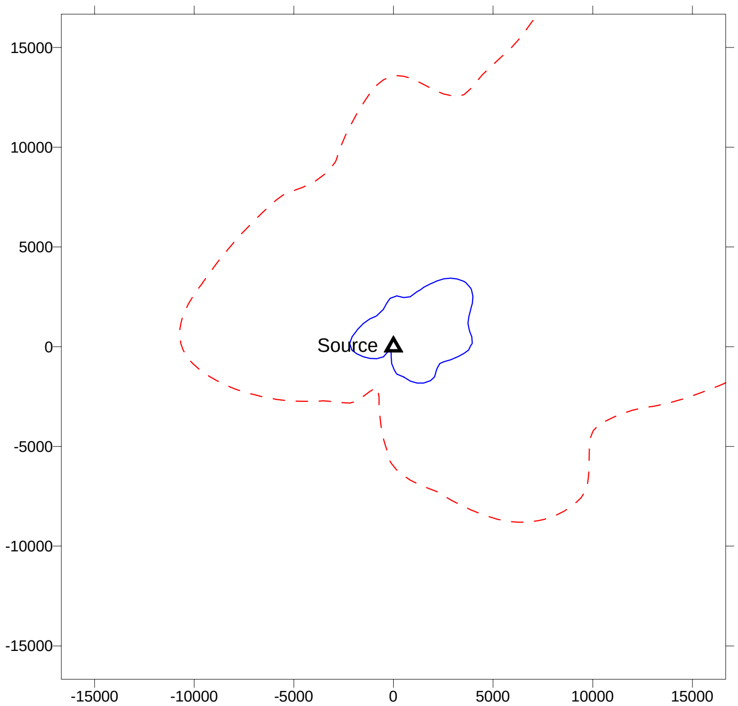


Figure 3.9. 10- and 1-in-a-million cancer risk isopleth. Large, downwash, urban, 24-hour, West Los Angeles.

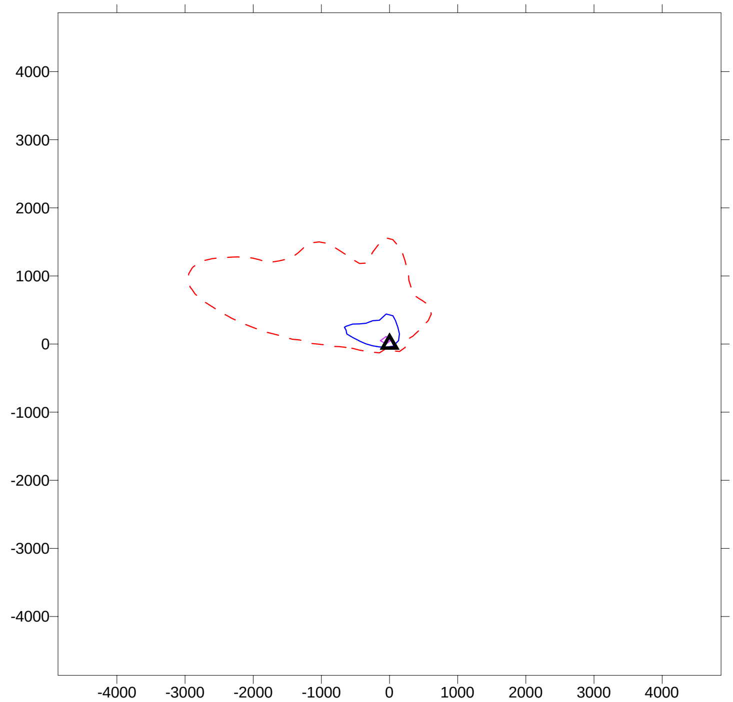


Figure 3.10. 10- and 1-in-a-million cancer risk isopleth. Medium, downwash, rural, 8-hour, Burbank

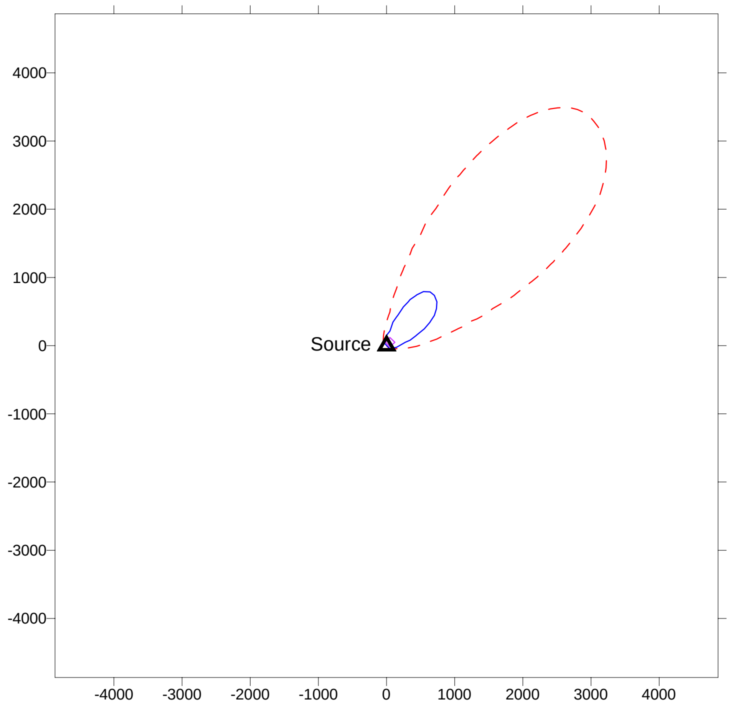


Figure 3.11. 10- and 1-in-a-million cancer risk isopleth. Medium, downwash, rural, 8-hour, West Los Angeles.

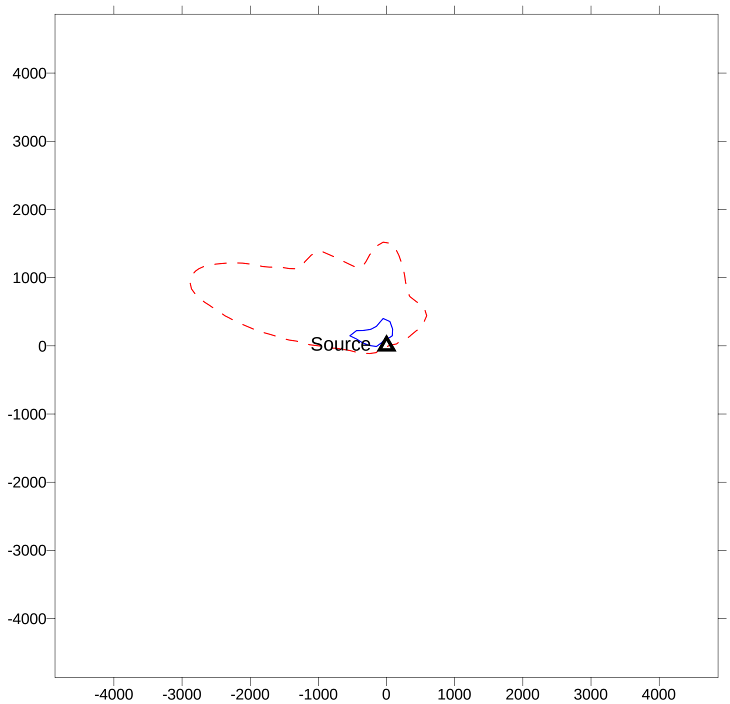


Figure 3.12. 10- and 1-in-a-million cancer risk isopleth. Medium, no downwash, rural, 8-hour, Burbank.

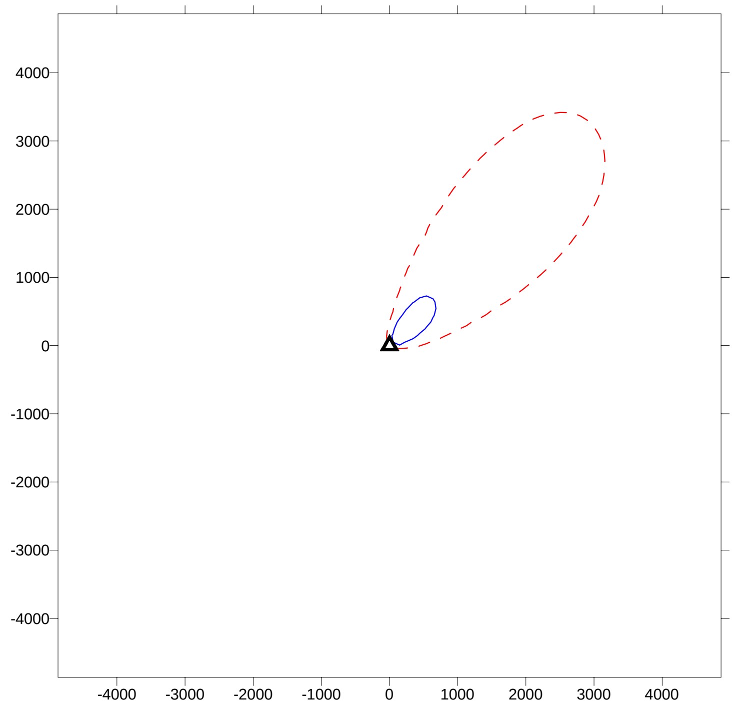


Figure 3.13. 10- and 1-in-a-million cancer risk isopleth. Medium, no downwash, rural, 8-hour, West Los Angeles.

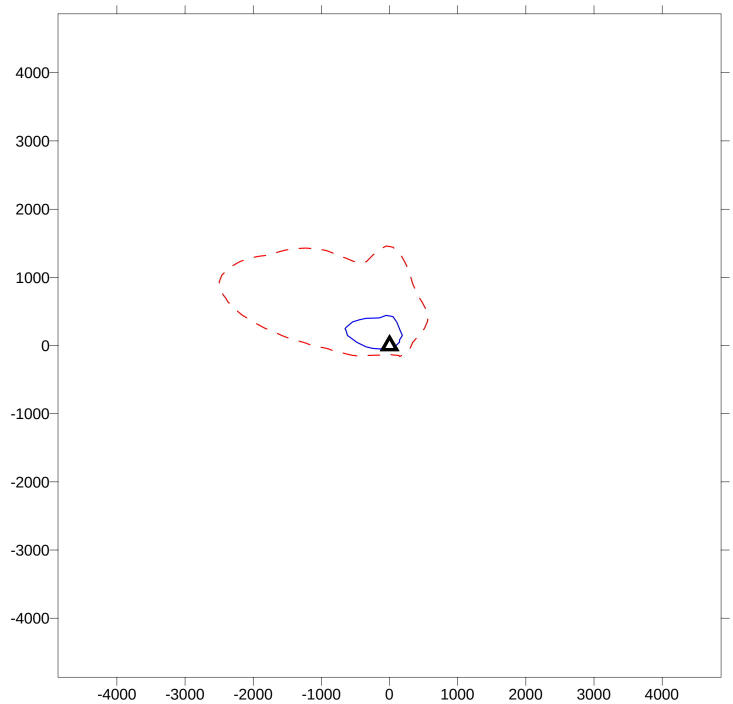


Figure 3.14. 10- and 1-in-a-million cancer risk isopleth. Medium, downwash, urban, 8-hour, Burbank.

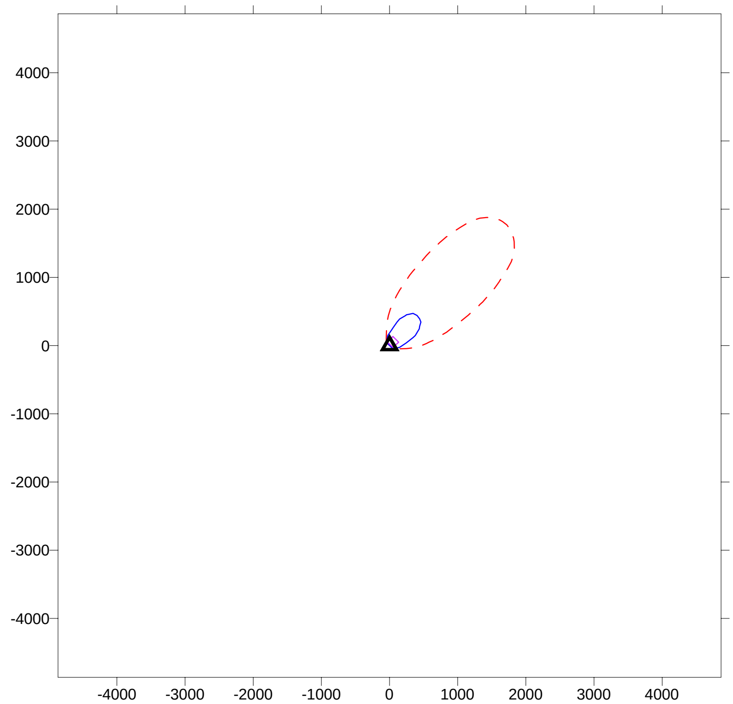


Figure 3.15. 10- and 1-in-a-million cancer risk isopleth. Medium, downwash, urban, 8-hour, West Los Angeles.

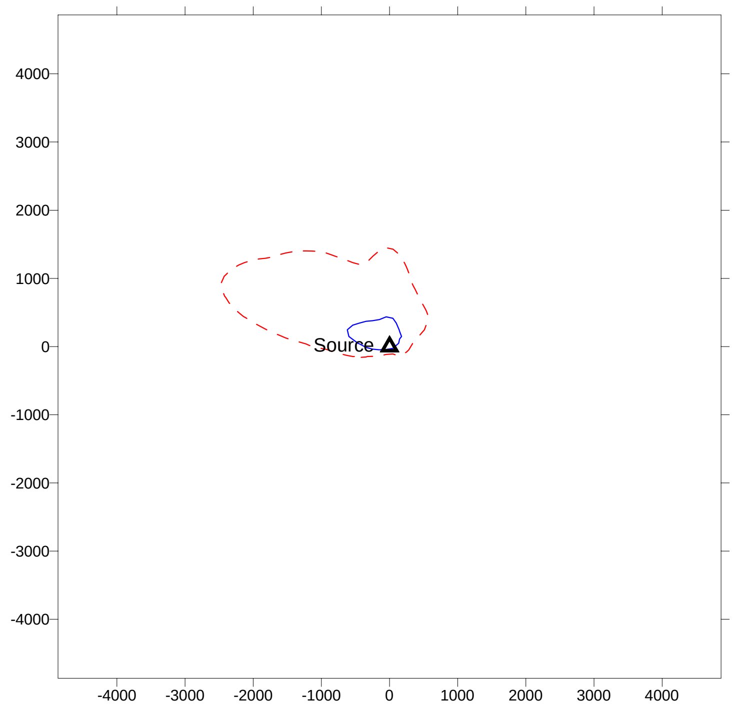


Figure 3.16. 10- and 1-in-a-million cancer risk isopleth. Medium, no downwash, urban, 8-hour, Burbank.

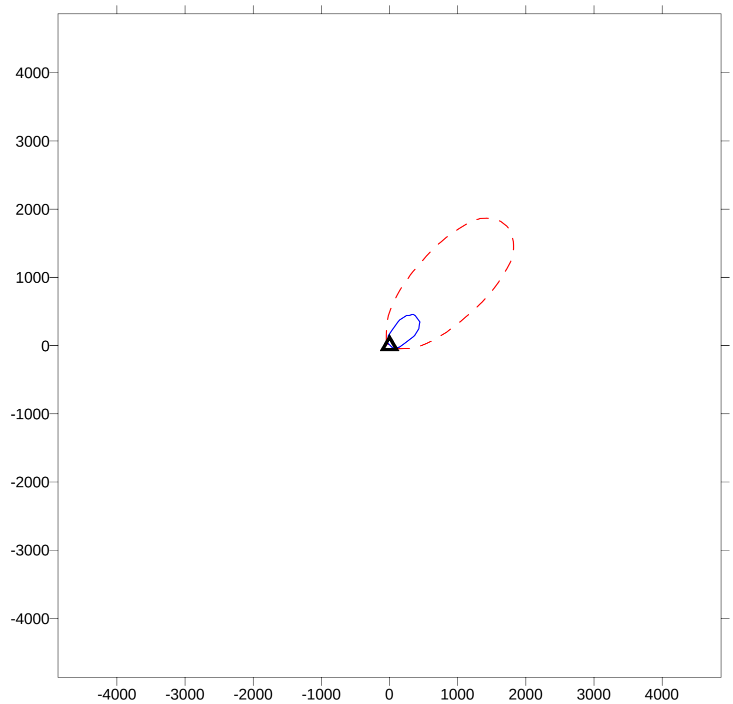


Figure 3.17. 10- and 1-in-a-million cancer risk isopleth. Medium, no downwash, urban, 8-hour, West Los Angeles.

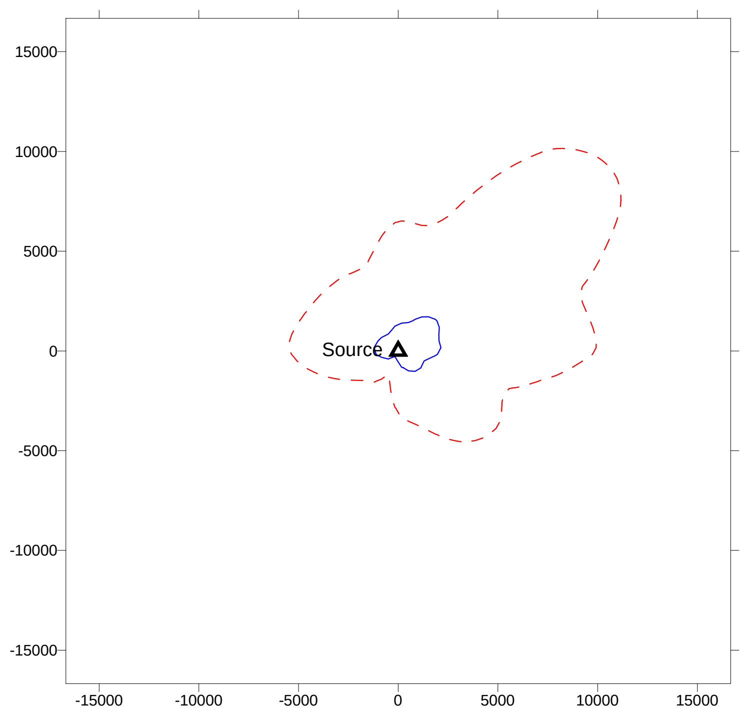


Figure 3.18. 10- and 1-in-a-million cancer risk isopleth. Medium, downwash, urban, 24-hour, West Los Angeles.

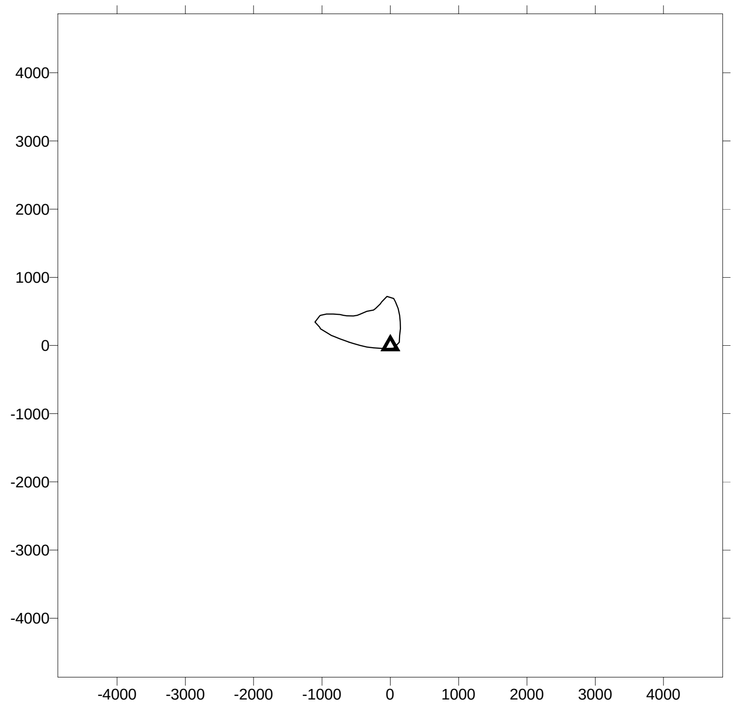


Figure 3.19. One μg/m^3 NO_2 isopleth. Large, downwash, rural, 8-hour, Burbank.

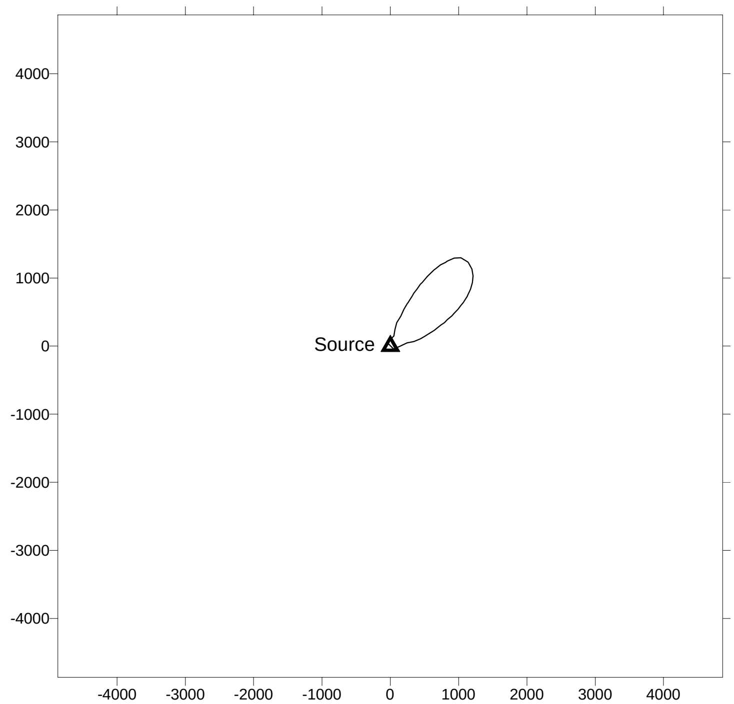


Figure 3.20. One μg/m^3 NO_2 isopleth. Large, downwash, rural, 8-hour, West Los Angeles.

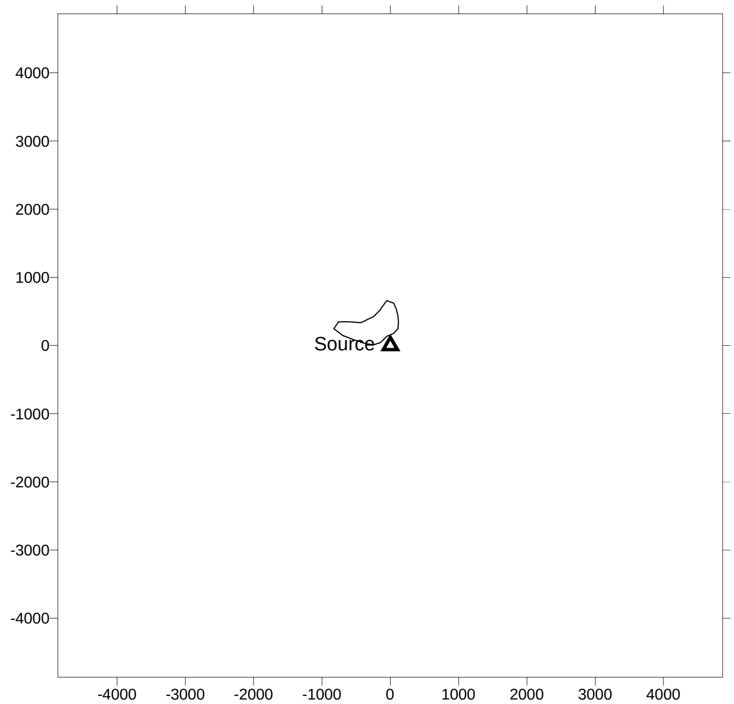


Figure 3.21 One μg/m^3 NO_2 isopleth. Large, no downwash, rural, 8-hour, Burbank.

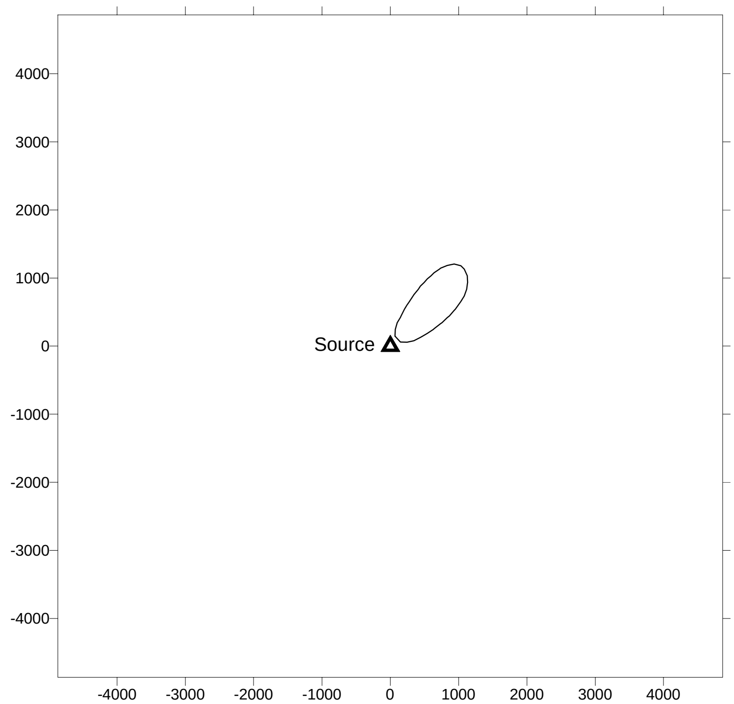


Figure 3.22. One μg/m^3 NO_2 isopleth. Large, no downwash, rural, 8-hour, West Los Angeles.

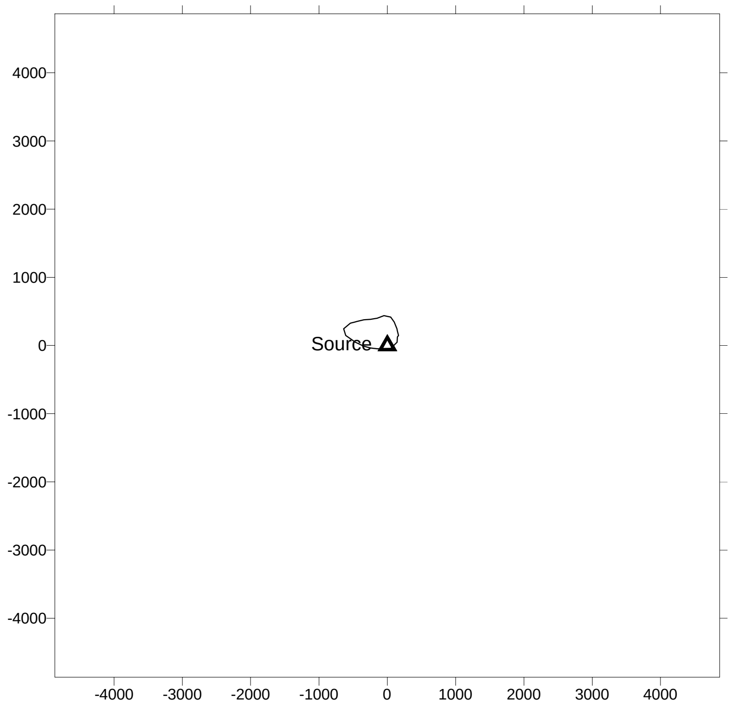


Figure 3.23. One μg/m^3 NO_2 isopleth. Large, downwash, urban, 8-hour, Burbank.

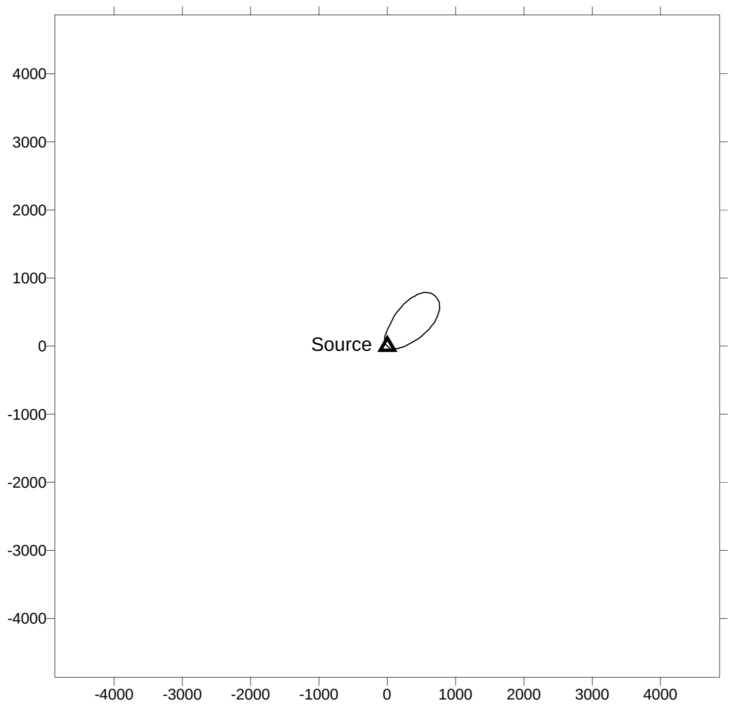


Figure 3.24. One μg/m^3 NO_2 isopleth. Large, downwash, urban, 8-hour, West Los Angeles.

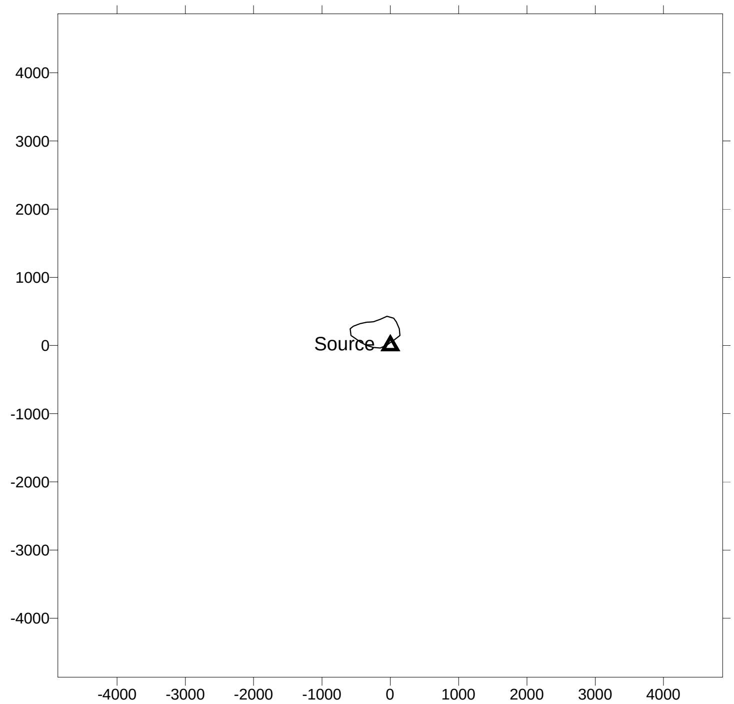


Figure 3-25. One µg/m^3 NO_2 isopleth. Large, no downwash, urban, 8-hour, Burbank.

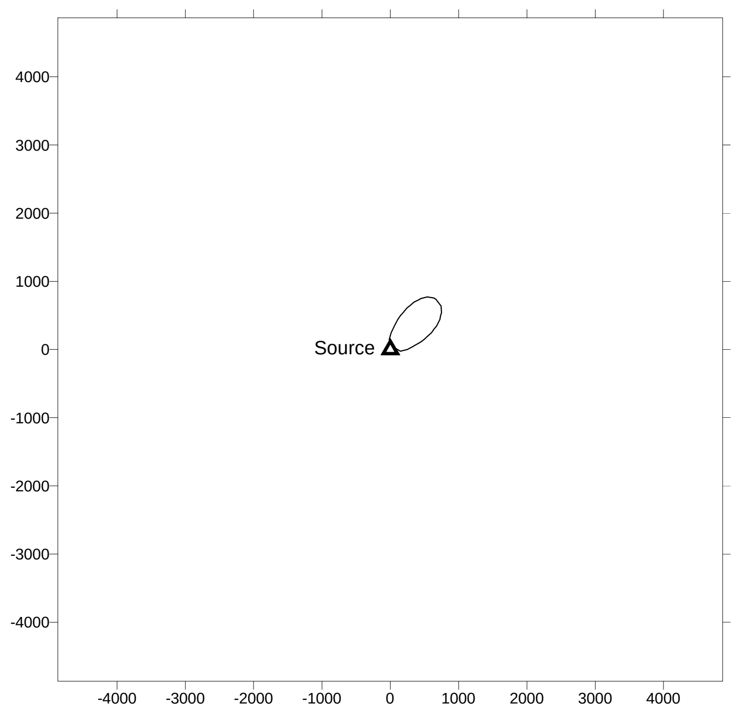


Figure 3-26. One µg/m^3 NO_2 isopleth. Large, no downwash, urban, 8-hour, West Los Angeles.

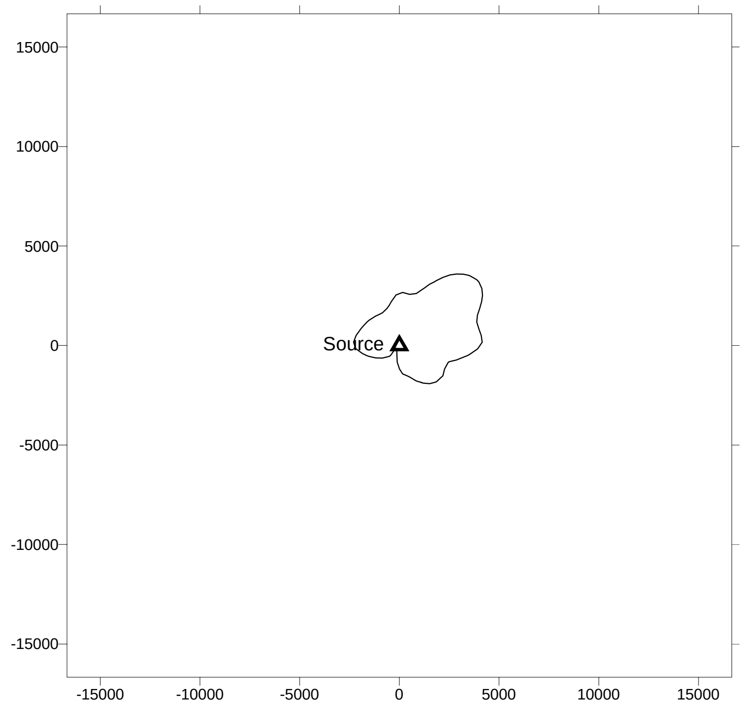


Figure 3.27. One µg/m^3 NO_2 isopleth. Large, downwash, urban, 24-hour, West Los Angeles.

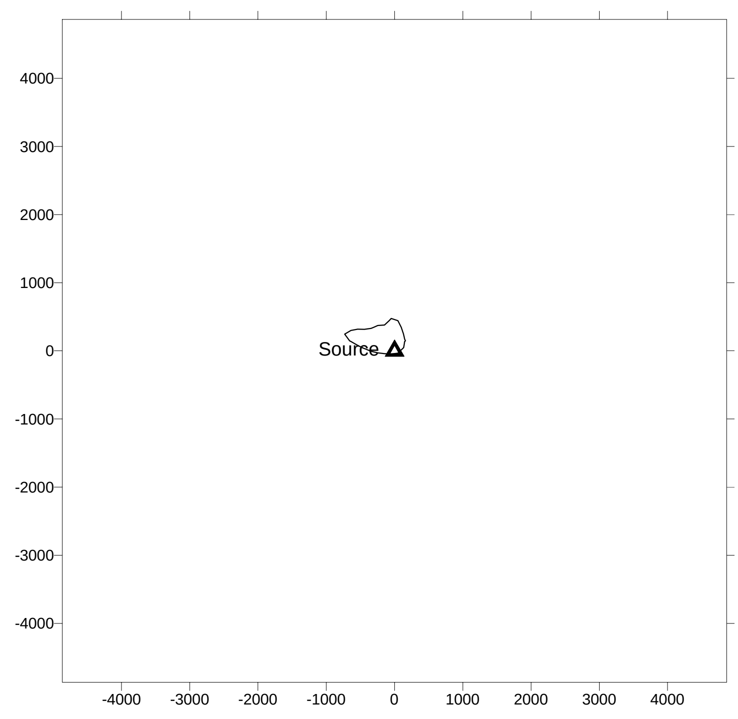


Figure 3.28. One µg/m^3 NO_2 isopleth. Medium, downwash, rural, 8-hour, Burbank.

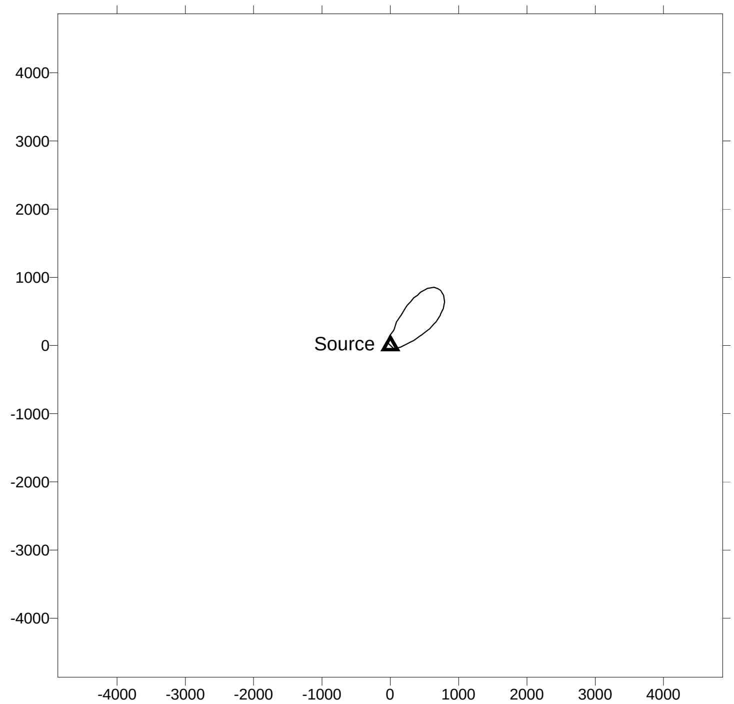


Figure 3.29. One µg/m^3 NO_2 isopleth. Medium, downwash, rural, 8-hour, West Los Angeles.

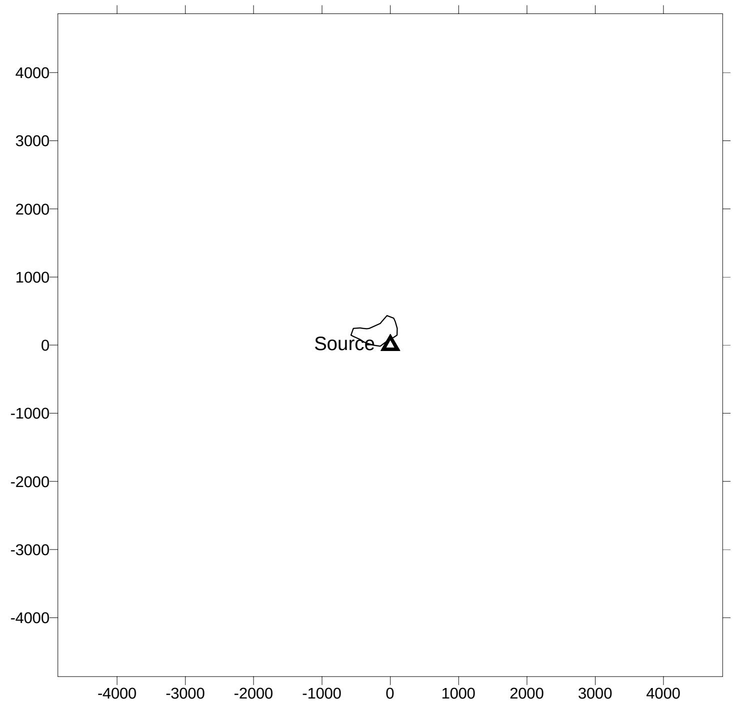


Figure 3.30. One µg/m^3 NO_2 isopleth. Medium, no downwash, rural, 8-hour, Burbank.

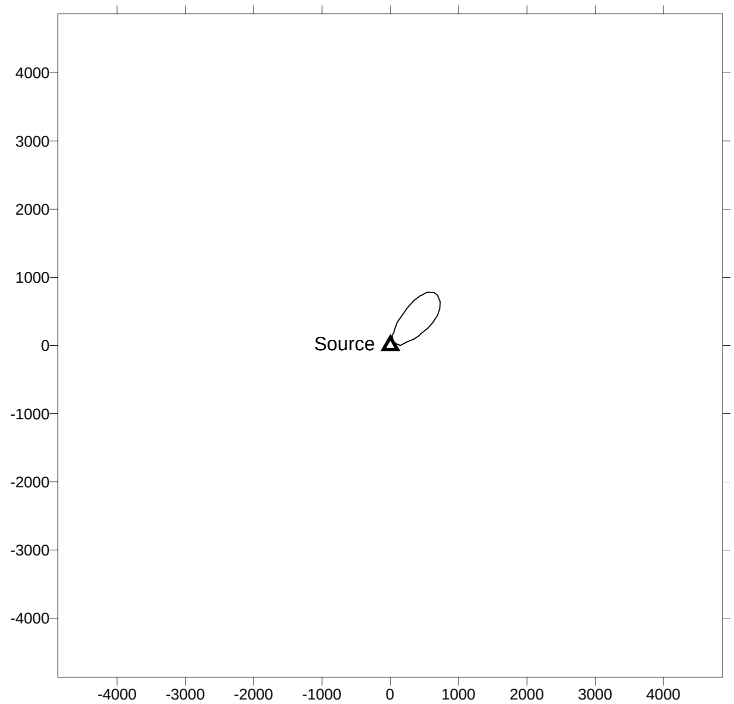


Figure 3.31. One µg/m^3 NO_2 isopleth. Medium, no downwash, rural, 8-hour, West Los Angeles.

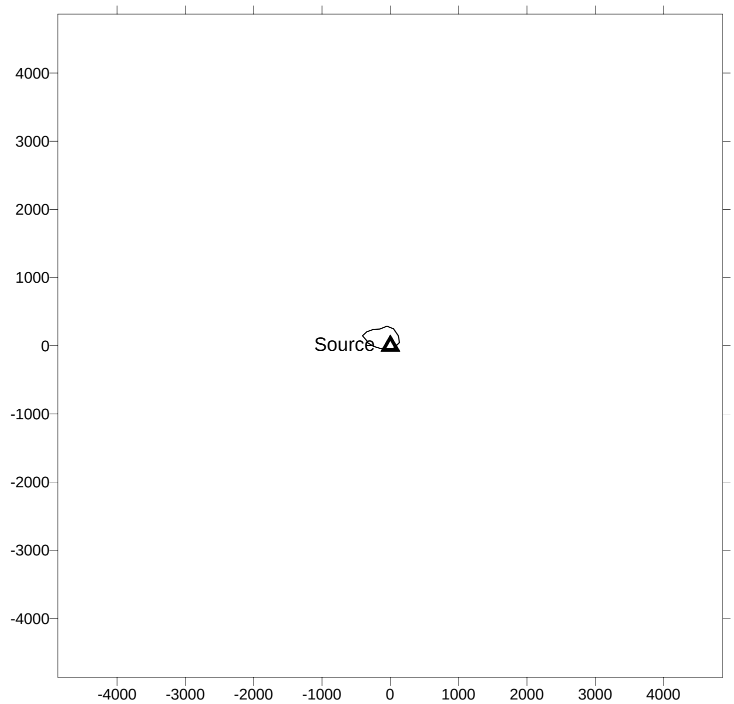


Figure 3.32. One µg/m^3 NO_2 isopleth. Medium, downwash, urban, 8-hour, Burbank.

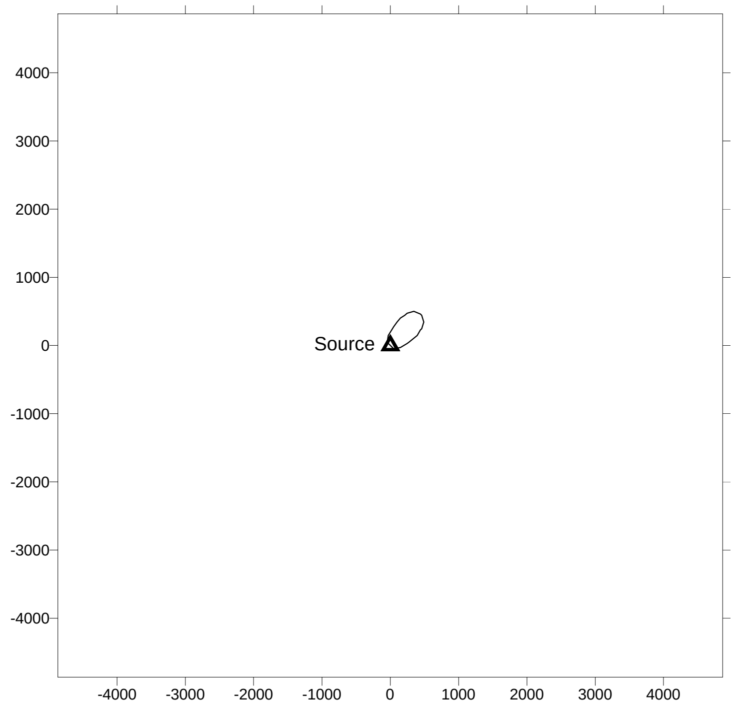


Figure 3.33. One $\mu g/m^3$ NO_2 isopleth. Medium, downwash, urban, 8-hour, West Los Angeles.

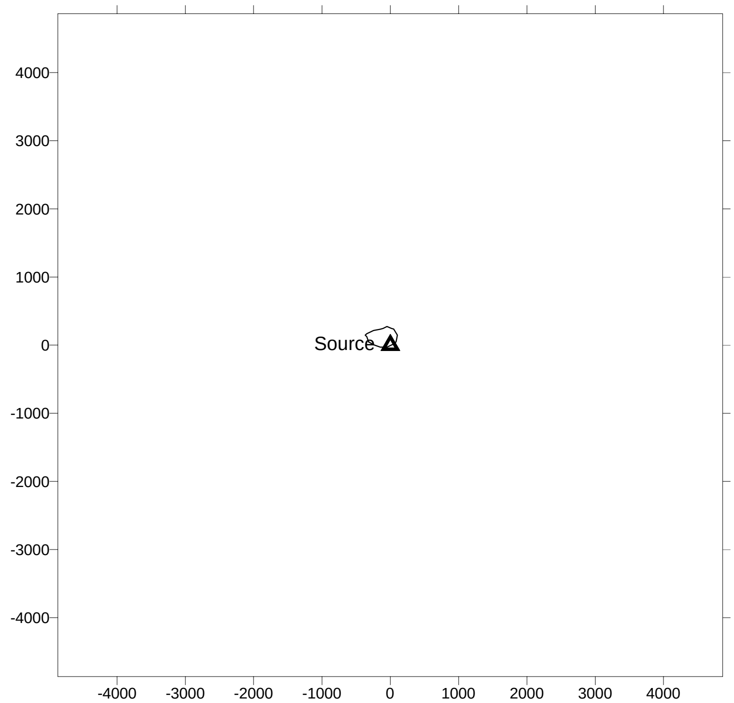


Figure 3.34. One $\mu g/m^3$ NO_2 isopleth. Medium, no downwash, urban, 8-hour, Burbank.

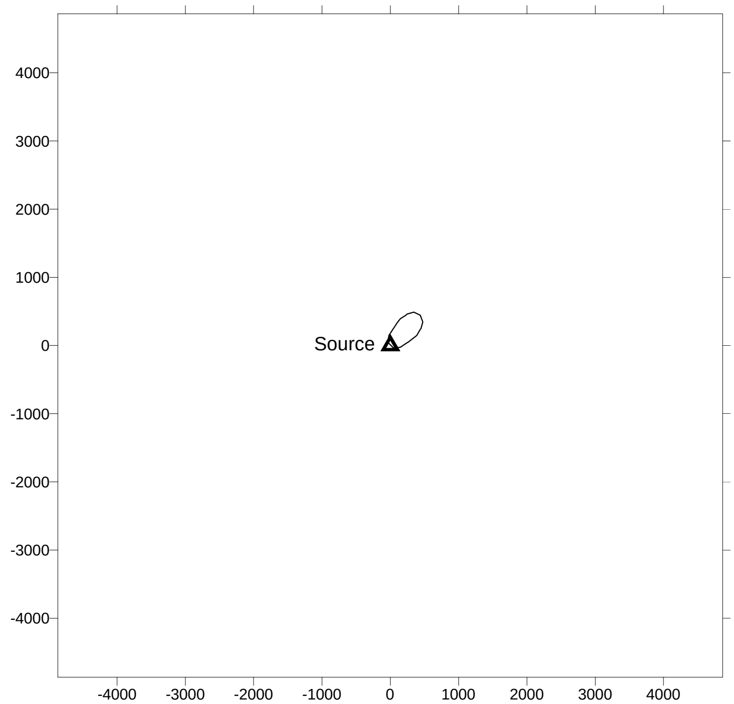


Figure 3.35. One μg/m^3 NO_2 isopleth. Medium, no downwash, urban, 8-hour, West Los Angeles.

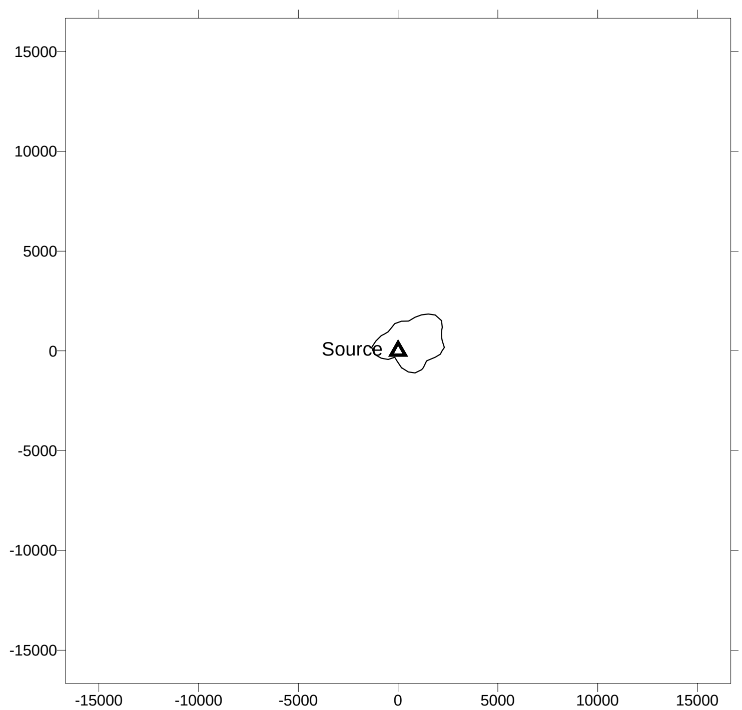


Figure 3.36. One μg/m^3 NO_2 isopleth. Medium, downwash, urban, 24-hour, West Los Angeles.

Appendix D

Background on Air Pollution Photochemistry

As discussed above, some pollutants are emitted directly as primary emissions, and the transport and dilution of these pollutants are best modeled at the local scale using simple dispersion models. At the urban and regional scale, however, we are most concerned with secondary pollutants, including O_3 and certain toxics and fine particulates, which are produced by photochemical reactions on time scales of hours to days and at distances on the order of 1 to 100 km from the emissions source region. Because photochemical production of O_3, PM and air toxics has a complex dependence on the magnitudes and ratio of the concentrations of the VOC and NO_X precursors species, we begin by reviewing gas phase photochemistry.

Production of secondary air pollutants is controlled by reactions of OH radicals with volatile organic compounds (VOC) and carbon monoxide (CO) in the presence of NO_X. For urban areas, the primary sources of initiation of OH radicals are photolysis reactions of carbonyls such as formaldehyde:

$$HCHO + hv \rightarrow CO + 2\ HO_2 \qquad R1$$

$$HO_2 + NO \rightarrow OH + NO_2 \qquad R2$$

Photolysis of O_3, is also a major source of OH production:

$$O_3 + hv \rightarrow O_2 + O(^1D) \qquad R3$$

$$O(^1D) + H_2O \rightarrow 2\ OH \qquad R4$$

Using methane (CH_4) as an example, reactions with OH and NO_X convert organic compounds to O_3 and carbonyls, as shown in R11:

$$OH + CH_4 + O_2 \rightarrow H_2O + CH_3O_2 \qquad R5$$

$$CH_3O_2 + NO \rightarrow CH_3O + NO_2 \qquad R6$$

$$CH_3O + O_2 \rightarrow HCHO + HO_2 \qquad R7$$

$$HO_2 + NO \rightarrow OH + NO_2 \qquad R8$$

$$2 \times (NO_2 + hv \rightarrow NO + O^3P) \qquad R9$$

$$2 \times (O^3P + O_2 \rightarrow O_3) \qquad R10$$

$$\text{Net Reaction: } CH_4 + 3\ O_2 \rightarrow H_2O + HCHO + 2\ O_3 \qquad R11$$

Thus, R5 through R10 propagate the initial molecules of OH and NO so that O_3 production can occur via a catalytic process without removing either OH or NO_X.

The rate of production of O_3 is reduced by reactions that block R5 through R10 either by destroying the free radicals in R12 through R16 or by converting NO_X to inert forms such as nitric acid (HNO_3), organic nitrates (RNO_3), particulate nitrate (NO_3^-), and peroxyacetyl nitrates (PAN) in R4 through R18:

$$HO_2 + HO_2 \rightarrow H_2O_2 + O_2 \quad R12$$

$$HO_2 + RO_2 \rightarrow ROOH + O_2 \quad R13$$

$$OH + NO_2 \rightarrow HNO_3 \quad R14$$

$$RO_2 + NO \rightarrow RNO_3 \quad R15$$

$$RO_3 + NO_2 \rightarrow PAN \quad R16$$

$$NO_3 + VOC \rightarrow RO_2 + HNO_3 \quad R17$$

$$N_2O_5 + H_2O \rightarrow 2\ HNO_3 \quad R18$$

It is important to note that reactions R14 to R18 also contribute to the formation of secondary fine particulates, for example:

$$HNO_3 + NH_3 \rightarrow NO_3^- NH_4^+ \quad R19$$

which can form new fine particulates or contribute to the growth of existing particulates by nucleation or condensation. Similarly, reaction of OH, O_3 and nitrate radicals with VOC can produce secondary organic species with low vapor pressure that form secondary organic aerosols. Thus, the gas phase chemistry that produces O_3 and HCHO is also directly responsible for the production of precursors to the secondary fine particulates.

Both the rate of production of O_3 and the sensitivity of O_3 to changes in emissions of the precursors VOC and NO_X has a complex dependence on the ratio of VOC to NO_X. For ambient conditions with high VOC and low NO_X concentrations, O_3 production is limited by the availability of NO in reactions R6 and R8:

$$CH_3O_2 + NO \rightarrow CH_3O + NO_2 \quad R6$$

$$HO_2 + NO \rightarrow OH + NO_2 \quad R8$$

For these high VOC/ NO_X conditions, O_3 production will decrease when NO_X emissions are reduced, and O_3 production is relatively insensitive to reductions in VOC. For ambient conditions with low VOC and high NO_X, the predominant reaction of OH is with NO_2 in R14, thereby blocking the O_3 production sequence beginning in R5. For these low VOC/NO_X ratios, O_3 production is limited by the availability of the OH radicals, and O_3 is very sensitive to changes in VOC. Moreover, O_3 production will decrease with increases in NO_X emissions because increasing NO_2 will destroy more OH radicals.

Increasing NO_X emissions can inhibit O_3 formation at low VOC/NO_X ratios; however, this effect is rarely observed for secondary PM. The NO_X inhibition effect on aerosol nitrates differ somewhat from the effect on O_3 because even as NO_2 inhibits the production of radicals, a larger fraction of OH radicals react with NO_2. Thus, R14 produces HNO_3 even it lowers the reactivity of the photochemical system. For an extreme case of NO_X inhibition, the system may become so unreactive that the rate of HNO_3 formation may decrease as well, but this effect is expected so smaller and less frequent than the inhibition effect on O_3. This result is apparent in the modeling results discussed below and presented in Appendix C.

It should be noted that the NO_X inhibition effect causes a reduce rate of destruction of O_3 precursors, and that increased transport of the NO_X and VOC precursors is expected to cause increased production rates of O_3 downwind. Moreover, dilution of these species during transport and dispersion will result in higher production efficiencies of O_3 per molecule of VOC and NO_X. Thus, the NO_X inhibition effect in urban areas will lead to a higher O_3 burden in downwind areas. However, because the O_3 and precursors are diluted by transport and dispersion, the peak O_3 levels may still be reduced.

Finally, it should be noted that there are large uncertainties in the chemical kinetics that affect the budgets of OH and NO_X and, furthermore, there are large uncertainties in the emissions and ambient concentrations of VOC and NO_X. Hence, there are large uncertainties in the ambient ratio of VOC and NO_X and in the sensitivity of O_3 to changes in VOC or NO_X emissions. Thus, the modeling results presented below are useful in understanding the dynamics of the photochemical system and the range of possible impacts of BUGs emissions. However, there are large uncertainties in the model predictions, and it is uncertain whether the current model simulation correctly predict effects of BUGs emissions on the magnitude or the direction in the change in O_3 and secondary PM. Current efforts are under way to further improve and validate the models used in this analysis. In addition, new model scenarios are being developed for recent field studies, and it is anticipated that future modeling results will provide more definitive guidance by the end of 2001.

Appendix E

Data on BUGs Operated on May 8, 2001

Total of SCE "Non-Firm" Customers that Operated BUGs on May 8, 2001						
Facility Name	**Facility Street Address**	**Latitude**	**Longitude**	**Size BUG (kW)**	**Operating Load (%)**	**Hours Operated**
American Savings Bank	4150 N. Palm St., FULLERTON, 92835	33.9168	-117.9270	750	Load Following	No data
Eisenhower Medical Center	39000 Bob Hope Dr., RANCHO MIRAGE, 9270	33.7682	-116.4080	1250	100	No data
Eisenhower Medical Center	39000 Bob Hope Dr., RANCHO MIRAGE, 9270	33.7682	-116.4080	1191	100	No data
Eisenhower Medical Center	39000 Bob Hope Dr., RANCHO MIRAGE, 9270	33.7682	-116.4080	2000	100	No data
Eisenhower Medical Center	39000 Bob Hope Dr., RANCHO MIRAGE, 9270	33.7682	-116.4080	1150	100	No data
Eisenhower Medical Center	39000 Bob Hope Dr., RANCHO MIRAGE, 9270	33.7682	-116.4080	1191	100	No data
Eisenhower Medical Center	39000 Bob Hope Dr., RANCHO MIRAGE, 9270	33.7682	-116.4080	2000	100	No data
Eisenhower Medical Center	39000 Bob Hope Dr., RANCHO MIRAGE, 9270	33.7682	-116.4080	950	100	No data
FDS Manufacturing Co. Inc.	2200 S. Reservoir St., POMONA, 91766	34.0318	-117.7320	993	100	No data
Irvine Ranch Water District	3512 Michelson Dr., IRVINE, 92612	33.6705	-117.8350	600	100	6
Irvine Ranch Water District	3512 Michelson Dr., IRVINE, 92612	33.6705	-117.8350	275	100	6
Irvine Ranch Water District	3512 Michelson Dr., IRVINE, 92612	33.6705	-117.8350	150	100	5
Irvine Ranch Water District	3512 Michelson Dr., IRVINE, 92612	33.6705	-117.8350	600	100	5
Irvine Ranch Water District	3512 Michelson Dr., IRVINE, 92612	33.6705	-117.8350	600	100	5
Irvine Ranch Water District	3512 Michelson Dr., IRVINE, 92612	33.6705	-117.8350	150	100	5
Irvine Ranch Water District	3512 Michelson Dr., IRVINE, 92612	33.6705	-117.8350	150	100	4

Total of SCE "Non-Firm" Customers that Operated BUGs on May 8, 2001 (Cont.)						
Kaiser Foundation Health Plan	1850 California Ave., CORONA, 92881	33.8504	-117.5390	1000	100	No data
Kaiser Foundation Health Plan	1850 California Ave., CORONA, 92881	33.8504	-117.5390	1750	100	No data
Kaiser Foundation Health Plan	1850 California Ave., CORONA, 92881	33.8504	-117.5390	1750	100	No data
Las Virgenes Municipal Water District	731 Malibu Canyon Rd,, CALABASAS, 91302	34.0821	-118.7050	1000	100	No data
Bercher Property Services (formerly Liu Corp.)	17011 Beach Blvd., HUNTINGTON BEACH, 92647	33.7153	-117.9890	357	Load Following	No data
Bercher Property Services (formerly Liu Corp.)	17011 Beach Blvd., HUNTINGTON BEACH, 92647	33.7153	-117.9890	357	Load Following	No data
Bercher Property Services (formerly Liu Corp.)	17011 Beach Blvd., HUNTINGTON BEACH, 92647	33.7153	-117.9890	357	Load Following	No data
MCI Group	18850 Orange St., BLOOMINGTON, 92316	34.0651	-117.3930	1430	100	5
MCI Group	18850 Orange St., BLOOMINGTON, 92316	34.0651	-117.3930	1430	100	5
MCI Group	18850 Orange St., BLOOMINGTON, 92316	34.0651	-117.3930	1233	100	5
MCI Group	18850 Orange St., BLOOMINGTON, 92316	34.0651	-117.3930	1233	100	5
Metropolitan Water District	33740 Borel Rd, WINCHESTER, 92596	33.5805	-117.0830	1033	65	4.7
Frito Lay	9535 Archibald Ave., RANCHO CUCAMONGA, 91730	34.1193	-117.5930	867	100	No data
Frito Lay	9535 Archibald Ave., RANCHO CUCAMONGA, 91730	34.1193	-117.5930	867	100	No data

Total of SCE "Non-Firm" Customers that Operated BUGs on May 8, 2001 (Cont.)						
Frito Lay	9535 Archibald Ave., RANCHO CUCAMONGA, 91730	34.1193	-117.5930	867	100	No data
CLVR WEST CNV HSPTL	4035 GRANDVIEW BLVD, CULVER CITY, 90230	n/a	n/a	10	80	6
DARIGOLD INCORPORATED now WESTFARMS FOODS	1474 N INDIANA ST., LOS ANGELES, 90063	N34-3.499'	W118-11.551'	600	100	6
KINGS, COUNTY OF	1220 W LACEY BLVD., HANDORD, 93230	N36-19.666	W119-28.764'	2000	39	7.5
LAS VIRGENES MUNICIPAL WTR DST	731 MALIBU CANYON RD., CALABASAS, 91302	34.0821	-118.7050	Unknown	Unknown	4.6
LAS VIRGENES MUNICIPAL WTR DST	731 MALIBU CANYON RD., CALABASAS, 91302	34.0821	-118.7050	Unknown	Unknown	4.6
LAS VIRGENES MUNICIPAL WTR DST	731 MALIBU CANYON RD., CALABASAS, 91302	34.0821	-118.7050	Unknown	Unknown	4.6
MONTEBELLO UNIFIED SCHOOL DIST	7800 SCOUT AVE., BELL GARDENS, 90201	n/a	n/a	Approximately 10 kW Onan natural gas gen.	Probably full load	unknown
TAMCO	12459 ARROW HWY., ETIWANDA, 91739	N34-5.940'	W117-34.155'	509	Unknown	5
TAMCO	12459 ARROW HWY., ETIWANDA, 91739	N34-5.940'	W117-34.155'	285	Unknown	5
METROPOLITAN WATER DISTRICT	33610 NEWPORT, HEMET, 92543	N33-41.133'	W116-58.791'	1000	60	4.7
			Average	998	95	5.1

Appendix F

District Rules and Policies for Backup Generators

(Updated April 10, 2002)

District	What BUGs Require Permits?	What Constitutes an Emergency?	How Long Can a BUG Run During an Emergency?	What Does It Take to Operate a Diesel Engine for Electrical Power Generation Outside an Emergency?
Amador County APCD *(all of Amador County)*	IC engines > than 1,000 bhp	Not defined	1,300 hrs/yr and not more than 66,000 gallons of diesel fuel per year (Alternative Operational Limit)	A valid permit
Antelope Valley APCD *(northeast portion of Los Angeles County)*	IC Engines > than 50 bhp	Not defined* *1/30/01 letter from APCO - a facility can operate during Stage 2/3 brownout or blackout with unlimited hours until 12/31/01	200 hrs/yr total includes testing and emergencies*	Can operate up to 200 hrs/yr as non-emergency. After 200 hrs/yr requires a valid permit.
Bay Area AQMD *(Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, western portion of Solano, southern portion of Sonoma counties)*	BUGs that emit > than 5 tons/yr of any criteria permit, or have interruptible contract	Blackout at facility	Current Exemption Level: 100 hours for testing in addition to 200 hrs/yr total includes emergency use. BACT/permit – If: No interruptible contract, < 5 tons/yr all criteria pollutants, HRA testing: 0.1 g/Bhp-hr PM_{10}, if > $1/10^6$ and < $10/10^6$, catalyzed diesel particulate filter if >$10/10^6$ Proposal for June: Emergency BUG Permit: 100 hours testing, unlimited use during emergency. 6.9 g/Bhp-hr, HRA testing (as above)	A valid permit

District	What BUGs Require Permits?	What Constitutes an Emergency?	How Long Can a BUG Run During an Emergency?	What Does It Take to Operate a Diesel Engine for Electrical Power Generation Outside an Emergency?
Butte County AQMD *(all of Butte County)*	Diesel-fired > than 50 bhp: Natural Gas, LPG, or Propane-fired > than 250 bhp	Any time commercial power is unavailable including, but not limited to, a brownout or rolling blackout, during the immediate preceding notification period, and power shortage itself; or during a declared stage-two or stage-three power shortage within a requested power curtailment period	Unlimited until offsets are required, then offsets must be obtained before additional operating time is authorized	A valid permit
El Dorado County APCD (*all of El Dorado County)*	IC Engines > than 50 bhp	When normal power line or natural gas service fails	200 hrs/yr total 50 hrs/yr for maintenance	A valid permit
Kern County APCD (*eastern portion of Kern County)*	IC Engines > than 50 bhp	During fuel or energy shortage	200 hrs/yr total	A valid permit
Mojave Desert AQMD *(northern portion of San Bernardino County, eastern portion of Riverside County)*	IC Engines > than 100 bhp	Blackout at facility *1/30/01 letter from APCO - a facility can operate during Stage 2/3 brownout or blackout with unlimited hours until 12/31/01	Unlimited during emergency	A valid permit
Monterey Bay Unified APCD *(all of Monterey, San Benito, Santa Cruz counties)*	IC Engines > than 100 bhp > than 50 bhp (multiple) +25 lb NO_X/day	Blackout at facility	Unlimited during emergency 60 hrs/yr for testing and maintenance	A valid permit Permit criteria include: NO_X offsets @ +137 lb/day BACT @ 6.9 NO_X @ 0.1 PM Risk Assessment

District	What BUGs Require Permits?	What Constitutes an Emergency?	How Long Can a BUG Run During an Emergency?	What Does It Take to Operate a Diesel Engine for Electrical Power Generation Outside an Emergency?
North Coast AQMD *(all of Del Norte, Humboldt, Trinity Counties)*	IC engines > than 50 bhp	Stage 2/3 emergency as declared by the ISO	100 hours for testing, unlimited use during emergency Must meet a PM emission rate of 0.1 g/bhp-hr	Greater than 100 hrs usage must have a screening health risk assessment BUGs with inhalation cancer risk greater than 10/million and less than 100/million must meet: a. PM rate of 0.02 g/bhp-hr; or b. Be equipped with a catalyst-based DPF or equivalent
Northern Sierra AQMD *(all of Nevada, Plumas, Sierra Counties)*	IC engines > than 1,000 bhp	Not defined	5,200 hrs/yr and not more than 265.000 gallons of diesel fuel per year	A valid permit
Sacramento Metro AQMD *(all of Sacramento County)*	IC Engines > than 50 bhp	Blackout at facility	100 hrs/yr testing/ maintenance 200 hrs/yr total (includes emergency use)	Loss of offset exemption. Trigger BACT, case-by-case BACT determination
San Diego County APCD *(all of San Diego County)*	IC Engines > than 50 bhp	At clock time (when State reserves are 3% or less and ISO forecasts a clock time state that reserves will fall to 2% or less)	Operate unlimited at time ISO forecast 2% clock time and 30 minutes after to shut down. Permits allow 52 to 100 hrs/yr for non-emergency use	A valid permit
San Joaquin Valley APCD *(all of Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, and western portion of Kern counties)*	IC Engines > than 50 bhp	During all stage 3 when there are rolling or imminent blackouts anywhere in San Joaquin Valley	No limit if used during emergency. 200 hrs/yr for testing	Can operate up to 1,000 hrs/yr if can meet a maximum of 6.9 g/Bhp-hr and diesel particulate filter. SCR is required if cost effective.

District	What BUGs Require Permits?	What Constitutes an Emergency?	How Long Can a BUG Run During an Emergency?	What Does It Take to Operate a Diesel Engine for Electrical Power Generation Outside an Emergency?
San Luis Obispo County APCD *(all of San Luis Obispo County)*	Newly installed (> 50 bhp) since 1/1/01	Blackout at facility	No limit during emergency Allows 100 hrs/yr for Testing and maintenance and demand relief.	< 100 hrs/yr have no additional requirements, >100 hrs/yr requires a permit and subject to New Source Review
Santa Barbara County APCD *(all of Santa Barbara County)*	IC Engines Greater than or equal to 100 bhp and operated greater than or equal to 200 hours per calendar year	Not defined in rule book; APCD guidance says operation of BUGs at "ISO Imminent Stage 3 Advisory" level or facility blackout is considered an emergency	200 hrs/yr includes emergency and testing use	< 200 hrs/yr has no additional requirements; greater than or equal to 200 hrs/yr requires a permit and subject to NSR
Shasta County AQMD *(all of Shasta County)*	IC Engines > 50 bhp	Any situation which requires the operation of IC engines to provide primary mechanical or electrical power in its abatement	No limit for emergencies 100 hrs/yr for testing and maintenance	Can operate up to 200 hrs/yr as non-emergency. After 200 hrs/year requires a valid permit
South Coast AQMD *(Los Angeles County except for Antelope Valley APCD, Orange County, western portion of San Bernardino and western portion of Riverside counties)*	IC Engines > than 50 bhp	Either Stage 2 or 3 has been declared or during blackout at facility	Up to 200 hrs/yr (500 hours for essential public service)	A valid Permit

District	What BUGs Require Permits?	What Constitutes an Emergency?	How Long Can a BUG Run During an Emergency?	What Does It Take to Operate a Diesel Engine for Electrical Power Generation Outside an Emergency?
Tehama County APCD *(all of Tehama County)*	Emergency standby engines must receive written District exemption. Subject to administrative requirements of Rule 4:34.	Blackout at the facility that is beyond the control of the owner or operator.	Unlimited during an emergency. 100 hrs/yr for testing and maintenance, or less based on risk assessment.	6.9 g/bhp-hr NO_X and 0.1 g/bhp-hr PM_{10}. 1. Screening Risk Assessment 2. BACT or T-BACT if applicable. 3. SF, Report from Office of Environmental Health and Hazardous Air Pollutants consultation, HRA and testing.
Ventura County APCD *(all of Ventura County)*	BUGs (> 50 bhp) that are used in a voluntary curtailment program or other interruptible agreement. BUGs used only for emergencies do <u>not</u> require a permit.	Blackout at facility	No limit during emergency. Up to 200 hrs/yr (which includes testing) for voluntary curtailment or interruptible power.	Existing BUGs were grandfathered for operation up to 200 hrs/yr. New BUGs (after 10/27/00) must meet NO_X of 6.9 g/bhp-hr and PM of 0.1 g/bhp-hr, and provide offsets if necessary, for operation up to 200 hrs/yr. For operation over 200 hrs/yr, abatement orders or compliance agreements.
Yolo-Solano AQMD *(all of Yolo and eastern portion of Solano counties)*	> 50 bhp	Blackout at facility	200 hrs/yr total includes testing and emergencies*	A valid permit

Appendix G

EOs Issued by the Davis Administration

EO #	Date	Order Summary	Relevance to BUGs
D-1-99	1-12-99	Authorizes disaster loan guarantee program for Monterey and Kings counties	None
D-2-99	1-12-99	Authorizes waiver of waiting period for unemployment insurance applicants affected by 12/98 freeze	None
D-3-99	2-17-99	Orders state's Year 2000 preparedness program	None
D-4-99	1-12-99	Establishes Commission on Building for the 21st Century and orders it to study the building and infrastructure needs for California	"building and infrastructure needs" could be understood to include BUGs
D-5-99	3-25-99	Establishes procedures for the removal of MTBE from the state's gasoline supply	None
D-6-99	5-4-99	Rescinds EO W-113-94	None
D-7-99	8-19-99	Establishes procedures for disposing of firearms possessed or confiscated by state agencies, departments, and boards	None
D-8-99	9-29-99	Orders contractors bidding on state projects to operate in a way that provides for the structural integrity and safety of California's roads, bridges, and government buildings	None

EO #	Date	Order Summary	Relevance to BUGs
D-9-99	10-7-99	Establishes procedure for implementing the federal Workforce Investment Act of 1998	None
D-10-99	10-15-99	Orders Executive Branch agencies, departments, boards, commissions, and offices to prevent and combat computer software piracy	None
D-11-99	11-4-99	Establishes the California Complete Count Committee and directs it to develop, recommend, and assist the administration of a strategy to encourage full participation in the 2000 federal decennial census of population	None
D-12-99	11-30-99	Constitutes a University of California, Merced Implementation Team to ensure the timely development of the UC Merced campus	None
D-13-00	12-16-99	Expands the UC Merced Implementation plan to include secretaries and directors of relevant state agencies, including: the Office of Planning and Research and the Office of the Secretary for Education	None

EO #	Date	Order Summary	Relevance to BUGs
D-14-00	8-2-00	Orders the timely implementation of the state's extant energy facility siting process; also requires the Energy Commission to propose legislation and/or regulations that would expedite this process.	None
D-15-00	8-2-00	Requires the immediate institution of energy conservation measures to reduce consumption in the case of an emergency; also orders monitoring of these efforts and the development of associated communications strategies.	None
D-16-00	8-2-00	Establishes a state sustainable building goal to create state buildings that are models of energy, water, and materials efficiency	"energy efficiency" may be understood to include BUGs
D-17-00	9-8-00	Establishes eGovernment	Computer infrastructure for the state government offices could require BUGs

D-18-01	2-1-01	In response to the State of Emergency proclaimed 1-17-01, Orders the Department of Consumer Affairs to conduct a media awareness campaign to inform the public on the importance of, and methods to, reduce energy consumption	Failure of methods to reduce energy consumption could necessitate the use of BUGs
EO #	**Date**	**Order Summary**	**Relevance to BUGs**
D-19-01	2-1-01	Orders all retail establishments to reduce outdoor lighting during non-business hours that is not necessary for the health and safety of the public, employees, or property	BUGs implicated to the extent that reduced lighting does not significantly reduce energy usage

EO #	Date	Order Summary	Relevance to BUGs
D-20-01	1-31-01	Commandeers the Block Forward market for the delivery of electricity possessed by Southern California Edison to be held subject to the control and coordination of the State of California	Relevant insofar as Southern California Edison owns and operates BUGs
D-21-01	1-31-01	Identical to D-201—1	Identical to D-20-21
D-22-01	2-8-01	Orders the Energy Commission to allow existing power plants to increase output between 6-1-01 and 10-01-01; also expedites the permit process for thermal power plants; and orders the State Water Resources Control Board (SWRCB) to allow waste discharge over thermal limit requirements; finally orders the SWRCB to contract for renewable power. Expired 12-31-01	None
D-23-01	2-8-01	Charges the Independent System Operator (ISO) to establish a protocol for and to institute rolling blackouts	Depending on the energy requirements needed to support even rolling blackouts, BUGs might be used. It is likely that high-tech and other energy-sensitive entities, such as hospitals, would use BUGs in the case of a blackout.

EO #	Date	Order Summary	Relevance to BUGs
D-24-01	2-8-01	Orders the Air Quality Management Districts (AQMDs) and Air Pollution Control Districts (APCDs) to modify emissions limits and limit hours of operations for air quality permits as needed to ensure power plants can provide power to the Department of Water Resources and are not restricted in their ability to operate; the districts shall require a mitigation fee for emissions in excess of previous emissions limits. Establishes an emissions reductions credit bank to manage environmental controls while increasing power production. Expired 12-31-01	Permits more extensive use of BUGs as needed.
D-25-01	2-8-01	Requires the Energy Resources Conservation and Development Commission to expedite the review and approval of post-certification amendments regarding thermal power plants; further orders the Energy Commission to suspend statute and regulatory requirements as needed for these reviews and approvals.	None

EO #	Date	Order Summary	Relevance to BUGs
D-26-01	2-8-01	Authorizes shortened review periods for some environmental documents prepared under the state's Environmental Quality Act; orders the Energy Commission to expedite licensing process for peaking or renewable power plants.	Relevant insofar as BUGs would fall under "peaking" power plant.
D-27-01	2-8-01	Requires the Department of Parks and Recreation to make remaining funds available to the Energy Resources Conservation and Development Commission to be used for performance awards related to the construction of power plants.	None

EO #	Date	Order Summary	Relevance to BUGs
D-28-01	3-7-01	Allows the Energy Resources Conservation and Development Commission and other reviewing agencies to modify procedural requirements, regulations, and statutes covered by EOs D-22-01, D-24-01, D-25-01, and D-26-01; procedures are exempt from the Administrative Procedure Act. States that the implementation of EOs D-22-01, D-24-01, D-25-01, and D-26-01 shall follow the substantive requirements designed to achieve environmental protection and protect public health and safety to the extent that they are consistent with the prompt execution of EOs. Limits permit modifications under EO D-24-01 to three years duration.	Would permit a more extensive use of BUGs
D-29-01	3-8-01	Declares the California Gambling Control Commission is prepared to assume the responsibilities and exercise the powers conferred by the Gambling Control Act	None

EO #	Date	Order Summary	Relevance to BUGs
D-30-01	3-13-01	Authorizes limited term rate reward program for conservation.	None, unless we imagine the use of BUGs to increase as a means of reducing the use of energy produced by central generators.
D-31-01	3-13-01	Delegates authority over tribal gaming to the Gambling Control Commission	None
D-32-01	4-26-01	Replaces D-27-01 and requires immediate relinquishing of Parks and Recreation funds. Expired 12-31-01.	None
D-33-01	4-26-01	Reduces the 20% reductions required by the limited term rate reward program established by D-30-01 to 15% for the customers of San Diego Gas and Electric Company (who had already reduced energy consumption by 7%)	None, except as for D-30-01
D-34-01	4-26-01	Orders the suspension or modification of procedures and regulations as needed to implement peak load reduction programs.	BUGs implicated to the extent that they constitute any part of the Energy Commission's peak load reduction programs.
D-35-01	5-8-01	Waives waiting period for all unemployment insurance applicants who are unemployed due to power outages resulting from a lack of electricity between 5-8-01 and 12-31-01.	None

EO #	Date	Order Summary	Relevance to BUGs
D-36-01	5-25-01	Orders expeditious implementation of existing energy conservation plans, and charges the State and Consumer Services Agency, the Department of General Services and the Energy Commission to implement, coordinate, and promote an aggressive energy conservation and demand reduction initiative. Also requires ongoing support activities, such as energy demand forecasting.	None
D-37-01	5-30-01	Increases state support for small business.	None
D-38-01	6-5-01	Orders that rolling blackouts be forecast and this information be made publicly accessible.	BUGs use as a potential recourse in the event of blackouts.
D-39-01	6-8-01	Charges the Department of Water Resources and the Independent System Operator to implement voluntary, emergency load curtailment programs for large customers of electric companies during the summer '01 and summer '02 seasons. Expires 10-31-02.	BUGs could be used as part of an emergency load curtailment program.

EO #	Date	Order Summary	Relevance to BUGs
D-40-01	6-11-01	In an effort to avoid the increased use of BUGs, directs local air districts to allow natural gas-fired power plants to operate in excess of any hourly, daily, quarterly, quarterly or annual emissions limits to: (1) sell power to the Department of Water and Power or a state utility, (2) serve the operating utility's own load, or (3) as ordered by the Independent System Operator. It further charges CARB to work with the U.S. EPA to ensure that power plants operating under this EO obtain any necessary approvals.	Reduces BUGs use.
D-41-01	6-15-01	Requires the California Department of Forestry and Fire Protection to deploy additional resources as needed to prevent and reduces losses due to seasonal wildfires.	None
D-42-01	6-18-01	Permits the Department of Water Resources to accept loans as needed to purchase electricity or natural gas to generate electricity.	None, except insofar as BUGs usage might decrease demand for centrally generated electricity and so also the need to purchase additional energy.
D-43-01	6-22-01	Promotes disabled veteran businesses.	None

EO #	Date	Order Summary	Relevance to BUGs
D-44-01	7-30-01	Suspends the Public Utility Code and any other relevant rules to the extent that they would prohibit the transfer of PG&E's Kern Power Plant to the North American Power Group.	None
D-45-01	9-19-01	Invokes the Emergency Services Act to order a waiver of the waiting period for all airline employees and other workers at California airports who were unemployed due to the economic impacts of the 9-11-01 terrorist attacks.	None
D-46-01	10-9-01	Orders the Department of General Services and other entities managing state properties and populated areas to give priority to those they serve that is consistent with the cost-effective use of state resources.	None
D-47-01	10-10-01	Directs the State Strategic Committee on Terrorism to ensure the state's readiness to respond to a terrorist attack.	None
D-48-01	10-23-01	Reduces or freezes hiring in and by the state pursuant to a significant economic downturn.	None

EO #	Date	Order Summary	Relevance to BUGs
D-49-01	10-23-01	Requires the Department of Finance to save at least $150 million in operating expenses and equipment expenditures for the remainder of the 2001–2002 fiscal year; this order extends to all state executive agencies and departments as appropriate.	None, except insofar as funding for research on BUGs could be threatened.
D-50-01	12-5-01	Prohibits the Department of Health Services from releasing birth and death indices to the public pending further public review.	None

Appendix H

Legal Opinion on Governor's Authority

PETER GREENWALD
Attorney at Law
712 RADCLIFFE AVE., PACIFIC PALISADES, CA 90272
TEL: (310) 459-2608 FAX: (310) 573-1885
pcg@speakeasy.net

September 17, 2001

Attorney-Client Confidential

Juliann Allison, Ph.D.
Department of Political Science
University of California, Riverside
2219 Watkins Hall
900 University Avenue
Riverside, CA 92521-1008

Re: Federal Clean Air Act Restrictions on Authority of Governor to Modify
Air Pollution Requirements

Dear Dr. Allison

I am writing in response to a request by the University of California, Riverside, College of Engineering Center for Environmental Research and Technology (CE-CERT) for an analysis of federal Clean Air Act restrictions on the authority of the Governor of California to modify air pollution requirements during an energy emergency. Specifically, you have requested an opinion regarding the following issues:

1. Does the federal Clean Air Act limit the authority of a state governor to modify, suspend or rescind air pollution control requirements during an energy emergency?

2. Does section 110(f) of the federal Clean Air Act, which authorizes state governors to, in an energy emergency, temporarily suspend air pollution control requirements in the State Implementation Plan (SIP) adopted pursuant to the Clean Air Act, authorize a governor to issue a "blanket" suspension applicable to an entire class of sources?

In brief, my conclusions are as follows:

1. Under the federal Clean Air Act and the United States Constitution, a governor does not have authority to modify, suspend or rescind federal air pollution laws, except as specifically allowed by the Clean Air Act. For purposes of this analysis, "federal air pollution control laws" include rules in a SIP adopted by state and local agencies that were approved by the United States Environmental Protection Agency (EPA) for inclusion in the SIP.

In order to modify, suspend or rescind requirements in the SIP due to an energy emergency, one of the following two procedures specified in the Clean Air Act must be completed:

(A) the state must adopt and obtain EPA approval of a SIP revision after providing for public notice and comment, or

(B) the governor must issue a temporary emergency suspension pursuant to Clean Air Act section 110(f), after—

(i) the President declares that a national or regional energy emergency exists of such severity that a temporary suspension of part of the SIP may be necessary, and other means of responding to the energy emergency may be inadequate, and

(ii) the governor finds that there exists in the vicinity of each source receiving a suspension an energy emergency involving high levels of unemployment or loss of necessary energy supplies for residential dwellings, and such unemployment or loss can be totally or partially alleviated by such emergency suspension.

Unless one of the above two procedures are completed, an order by the governor modifying, suspending or rescinding a requirement that has been approved by EPA for inclusion in the SIP would—at most—prevent enforcement of that requirement by state and local officials. Such action by the governor would not relieve sources of the obligation to comply with the EPA-approved SIP provision, or prevent enforcement of the SIP provision by the federal government or citizens. Thus, any emergency authority of the governor to modify, suspend or rescind air pollution requirements is, absent a presidential declaration of emergency under section 110(f), effectively limited to modifying, suspending or rescinding requirements that were adopted by state or local governments and that are not in the SIP.

2. Section 110(f) requires the governor to make findings of fact that apply to each source that would be covered by a suspension. The statute, however, is not clear regarding whether or not a single set of findings could apply to all sources in a category. It is my opinion that the most supportable interpretation—and the one that a court is most likely to accept—is that section 110(f) requires a case-by-case determination, including findings of fact explicitly referencing and related to each source subject to an emergency suspension. This interpretation would preclude the issuance of a blanket suspension applicable to all sources in a category. Given the statutory language, however, it is by no means certain that a court would agree with this conclusion where identical findings could apply to many sources.

ANALYSIS

Background—Governor's Authority Under California Emergency Services Act

The California Emergency Services Act, Gov't. Code §8550 et seq, authorizes the Governor to make, amend, and rescind regulations during a declared "state of emergency."[1] Section 8567states:

> The Governor may make, amend, and rescind orders and regulations necessary to carry out the provisions of this chapter. The orders and regulations shall have the force and effect of law. Due consideration shall be given to the plans of the federal government in preparing the orders and regulations. §8567(a).[2]

Section 8571 of the Emergency Services Act provides:

> During a state of war emergency or a state of emergency the Governor may suspend any regulatory statute, or statute prescribing the procedure for conduct of state business, or the orders, rules, or regulations of any state agency, including subdivision (d) of Section 1253 of the Unemployment Insurance Code, where the Governor determines and declares that strict compliance with any statute, order, rule, or regulation would in any way prevent, hinder, or delay the mitigation of the effects of the emergency. §8571.

During a state of emergency, the governor also has "complete authority over all agencies of the state."[3]

---

[1] The Act provides defines a "state of emergency" as follows:

> "State of emergency" means the duly proclaimed existence of conditions of disaster or of extreme peril to the safety of persons and property within the state caused by such conditions as air pollution, fire, flood, storm, epidemic, riot, drought, *sudden and severe energy shortage*, plant or animal infestation or disease, the Governor's warning of an earthquake or volcanic prediction, or an earthquake, complications resulting from the Year 2000 Problem, or other conditions, other than conditions resulting from a labor controversy or conditions causing a "state of war emergency," which, by reason of their magnitude, are or are likely to be beyond the control of the services, personnel, equipment, and facilities of any single county, city and county, or city and require the combined forces of a mutual aid region or regions to combat, *or with respect to regulated energy utilities, a sudden and severe energy shortage requires extraordinary measures beyond the authority vested in the California Public Utilities Commission.* §8558(b)(emphasis added).

[2] All references are to the California Government Code unless otherwise noted.

[3] The Act states:

> During a state of emergency the Governor shall, to the extent he deems necessary, have complete authority over all agencies of the state government and the right to exercise within the area designated all police power vested in the state by the Constitution and laws of the State of California in order to effectuate the purposes of this chapter. In exercise thereof, he shall promulgate, issue, and enforce such orders and regulations as he deems necessary, in accordance with the provisions of Section 8567. §8627.

The preceding statutes provide the governor explicit authority to suspend *state* statutes and regulations of *state* agencies during a declared emergency. Air pollutant emissions in California are governed by such state statutes and regulations, but also are governed regulations promulgated by local agencies such as air quality districts. The Emergency Services Act does not explicitly state that the governor may take actions that affect regulations adopted by local agencies, but the governor likely has sufficient authority under that Act to do so.[4]

Applicability of California Emergency Services Act to Federal Laws

As is described below, air pollutant emissions in California are not only governed by laws promulgated by state and local governments, but also are governed by federal laws—primarily the Clean Air Act. 42 U.S.C. §7401 *et seq*. The California Emergency Services Act does not explicitly purport to authorize the governor to amend, suspend or rescind federal laws. The Act does declare legislative intent that emergency services functions of the state be coordinated as far as possible with comparable functions of the federal government. §8550. Similarly, section 8567, which authorizes the governor to make, amend or rescind regulations during a declared emergency, states that "Due consideration shall be given to the plans of the federal government in preparing the orders and regulations." Neither of these provisions, however, purport to authorize the governor to amend, suspend or rescind federal law.

Section 8567(a), which generally authorizes the governor to "make, amend, and rescind orders and regulations," does not specify that its scope is limited to orders and regulations adopted by state or local governments. However, an interpretation of the California Emergency Services Act that authorizes the governor to amend, suspend or rescind federal statutes or regulations, would, absent specific federal statutory authorization (such as in section 110(f) of the federal Clean Air Act, discussed below) run afoul of the United States Constitution. Such authority, if claimed by a state, would undoubtedly be struck down under the Supremacy Clause of the United States Constitution, which provides that the laws of the United States are the supreme law of the land. U.S. Const. Art. VI cl.2; *see* 81A C.J.S. §§ 22, 24.

Thus, the governor may not utilize authority under the Emergency Services Act to amend, suspend or rescind requirements of the federal Clean Air Act. As is described

[4] A full discussion of any limitations on the governor's emergency authority over local laws is beyond the scope of this analysis. I note, however, that section 8571 only authorizes the governor to suspend regulations "of any state agency." Air quality districts in California are not "state agencies," they are local or regional authorities. *See* Cal. Health & Saf. Code § 40,000. Section 8567(a) is more general; it simply authorizes the governor to make, amend or rescind "regulations." As a practical matter, the governor could suspend the authority to enforce regulations adopted by local districts because the authorities necessary to enforce such local rules are found in state statutes. *E.g.* Health & Safety Code §42400 et seq. In addition, authorities and responsibilities of local air quality districts are comprehensively governed by state statutes. *See* Division 26. Cal. Health and Saf. Code.

below, the Clean Air Act imposes requirements and restrictions on the state's—and the governor's—authority to amend, suspend or rescind air pollution control requirements.

Federal Clean Air Act Restrictions Regarding Revision of Pollution Rules

SIPs. The federal Clean Air Act requires each state to adopt a SIP that includes air quality laws adequate to achieve the National Ambient Air Quality Standards (NAAQS). In California, state statutes specify that local air quality districts have responsibility for adopting rules applicable to stationary sources within their jurisdictions to achieve the NAAQS. Upon approval by the California Air Resources Board, such rules constitute a proposed portion of the California SIP. The rules are then forwarded by CARB to the Administrator of the United States Environmental Protection Agency ("EPA") for federal approval as part of the SIP. *See e.g.* Health & Saf. Code §§39602, 40,001.

Once such rules are approved by EPA for inclusion into the SIP, they become federally enforceable pursuant to provisions of the Clean Air Act. The Act authorizes EPA as well as citizens to take various actions to enforce SIP provisions. §113, 42 U.S.C. §7413 (EPA enforcement authorities); §304, 42U.S.C. §7604 (authorizing citizen suits against sources violating an emission limitation in a SIP). SIP provisions thus are enforceable by state or local authorities, as authorized by state law, as well as by the federal government and citizens, pursuant to the Clean Air Act.

Procedure to Revise SIP. Proposed revisions to the EPA-approved SIP may only be adopted by the state after providing notice and opportunity for public comment. §110(a)(2); 42 U.S.C. §7401(a)(2). EPA action on proposed SIP revision can take many months (see Clean Air Act §110(k), 42 U.S.C. §7401(k)[EPA time limits to act]); the federal agency must find that the revision will not interfere with timely attainment of air quality standards or any other applicable requirement of the Act. §110(l), 42 U.S.C. §7401(l).

If the state acts to modify a provision in a SIP, for example by making it more lenient, the previous version in the SIP may continue to be enforced pursuant to the Clean Air Act unless and until EPA approves a SIP revision incorporating the revised provision. *U.S. v. General Motors Corp.*, 110 S.Ct. 2528, 496 U.S. 530, 110 L.Ed2d 480 (1990).

Governor's Authority to Amend, Suspend or Rescind Provisions of SIP. As was described above, under the Clean Air Act, if an air pollution control requirement that has been approved by EPA for inclusion in the SIP is relaxed, suspended or rescinded by state or local officials, such action will have no effect on the authority of the federal officials or citizens groups to bring enforcement actions against sources violating the federally-approved provision. There is no reason why this principle would be different if the state official modifying the SIP is the governor rather than state or local air quality agencies. Such an action by the governor thus would be ineffective to relieve sources of the obligation to comply with the EPA-approved SIP, or to prevent enforcement of the SIP by the federal government or citizens. The most significant potential effect of a governor's order modifying, suspending or rescinding a SIP requirement would be to prevent enforcement of that requirement by state and local officials. A court may conclude, however, that even this effect may not lawfully occur. Section 116 of the Clean Air Act provides that "if an emission standard or limitation is in effect under an applicable implementation plan . . . , such State or political subdivision may not adopt or enforce any emission standard or limitation which is less stringent than the standard or limitation under such plan . . . ."[5] Thus, if the governor, in modifying, suspending or rescinding a SIP provision, attempts to adopt or enforce an emission standard or requirement that is less stringent than the SIP, a court could conclude that such actions are preempted by section 116 of the Act.

Energy Emergency Provisions of the Federal Clean Air Act.

Section 110(f). Section 110(f) of the federal Clean Air Act, 42 USC §7410(f), authorizes a state governor to issue a "temporary emergency suspension" of a SIP provision if the President determines that a national or regional energy emergency of requisite severity exists. The subsection states in pertinent part—

> (1) Upon application by the owner or operator of a fuel burning stationary source, and after notice and opportunity for public hearing, the Governor of the State in which such source is located *may petition the President to determine that a national or regional energy emergency exists of such severity that –*
>
> (A) *a temporary suspension of any part of the applicable implementation plan* or of any requirement under section 7651j of this title (concerning excess emissions penalties or offsets) *may be necessary, and* (B) *other means of responding to the energy emergency may be inadequate.* Such determination shall not be delegable by the President to any other person. *If the President determines that a national or regional energy emergency of such severity exists, a temporary emergency suspension of any part of an applicable implementation plan* or of any requirement under section 7651j of this title (concerning excess emissions penalties or offsets) adopted by the State *may be issued by the Governor* of any State covered by the President's determination

[5] Section 116, 42 U.S.C. §7416, states:

> Except as otherwise provided in sections 119 (c), (e), and (f)(as in effect before the date of the enactment of the Clean Air Act Amendments of 1977), 209, 211(c)(4), and 233 (preempting certain State regulation of moving sources) nothing in this Act shall preclude or deny the right of any State or political subdivision thereof to adopt or enforce (1) any standard or limitation respecting emissions of air pollutants or (2) any requirement respecting control or abatement of air pollution; except that *if an emission standard or limitation is in effect under an applicable implementation plan* or under section 111 or 112, *such State or political subdivision may not adopt or enforce any emission standard or limitation which is less stringent* than the standard or limitation under such plan or section. 42 U.S.C. 7416 (emphasis added).

> under the condition specified in paragraph (2) and may take effect immediately.
>
> (2) A temporary emergency suspension under this subsection shall be issued to a source *only if the Governor of such State finds that –*
>
> (A) *there exists in the vicinity of such source a temporary energy emergency involving high levels of unemployment or loss of necessary energy supplies for residential dwellings; and (B) such unemployment or_loss can be totally or partially alleviated by such emergency suspension.* Not more than one such suspension may be issued for any source on the basis of the same set of circumstances or on the basis of the same emergency.
>
> (3) A temporary emergency suspension issued by a Governor under this subsection shall remain in effect for a maximum of four months or such lesser period as may be specified in a disapproval order of the Administrator, if any. The Administrator may disapprove such suspension if he determines that it does not meet the requirements of paragraph (2) . . . . (emphasis added).

Interpretation of Statutory Language. The following conclusions can be gleaned from the language of subsection 110(f): First, the governor is only authorized to issue a temporary emergency suspension if the President has determined that a national or regional energy emergency of the severity specified in subparagraph (1)(A) exists.[6] If the President has not made such a determination, the principles described in the previous section of this opinion apply, i.e. the governor may not prevent EPA or citizens from enforcing a federally-approved SIP provision pursuant to the Clean Air Act.

Second, if the President has made the required determination that a national or regional energy emergency exists, a governor may only issue an emergency suspension if he or she makes the findings described in paragraph (2). The section clearly requires that the governor make the specified findings of fact applicable to each source that would be covered by a suspension.[7]

---

[6] The statute contains other procedures related to emergency suspensions. For example, it specifies that the governor "may" petition the president for a determination that an emergency exists "upon application by the owner or operator of a fuel burning stationary source, and after notice and opportunity for public hearing." I express no opinion in this letter regarding the validity of an emergency suspension issued without a petition to the president requested by a source, or without public notice and opportunity for hearing.

[7] This is supported by the following language of section 110(f)(2):

> A temporary emergency suspension under this subsection shall be issued to a source only if the Governor of such State finds that (A) there exists in the vicinity of *such source* a temporary energy emergency involving high levels of unemployment or loss of necessary energy supplies for residential dwellings; and (B) such unemployment or loss can be totally or partially alleviated by such emergency suspension. (emphasis added).

The more difficult question—and the question presented by your request—is whether or not a governor may issue a temporary emergency suspension for an entire class of sources, or, alternatively, must a temporary emergency suspension be issued on a "case-by-case" basis to each source. The question devolves down to whether or not each source must be explicitly identified in the order of suspension, and—more significantly under the statute—whether or not a single set of findings could apply to all sources covered by the suspension. Such a situation could theoretically arise where the findings would be identical for each source affected by a suspension. Given the nature of the required findings, this seems theoretically possible, for example, if there is a statewide energy shortage that could be alleviated by additional contribution of generation from numerous sources.

This question presents an issue of statutory interpretation. There are no judicial decisions that interpret the language at issue here. We therefore must resort to applying general maxims of statutory construction. In general, such maxims require the courts to follow unambiguous language in a statute, and, in the event of ambiguity, attempt to effectuate Congress' intent. The courts may consider legislative history in attempting to ascertain Congress' intent. Further guidance in interpreting an ambiguous statute may be provided by administrative agencies charged with its enforcement. While not binding on the courts, such interpretations are accorded deference. *Chevron U. S. A. Inc. v. Natural Resources Defense Council, Inc., Et Al.* 467 U.S. 837; 104 S. Ct. 2778; 81 L. Ed. 2d 694 (1984).

The language of the statute does not explicitly address the question of whether the governor may issue a "blanket" suspension for all sources in a class. The statute does, however, in various places refer to the issuance of an emergency extension in the context of a specific source. For example, the governor is authorized to petition the President "upon application by the owner or operator of *a fuel burning stationary source;*" the statute says that "the Governor of the State in which *such source is located* may petition the President;" a temporary emergency suspension may "be issued *to a source;*" and the Governor must find that "there exists *in the vicinity of such source* a temporary energy emergency." (emphasis added).

The legislative history of this provision is not particularly helpful in ascertaining Congress' intent on this issue, but it does refer to "particular sources." Section 110(f) was amended into its current from as part of the Clean Air Act Amendments of 1977. According to the House Report regarding these amendments, the provision was an attempt to address situations such as a fuel shortage that occurred in the winter of 1977. The Report said:

> The committee recognizes that certain untoward circumstances could precipitate an economic or energy crisis which would necessitate a temporary suspension of the provisions of an implementation plan *as applied to particular sources*. To

> provide for this emergency ability, the committee adopted section 115 of the bill. (emphasis added).[8]

EPA Memoranda. EPA is charged with implementing a portion of section 110(f) since it has authority under paragraph (3) to disapprove a suspension. EPA has published three guidance documents on its web site relating to section 110(f). Two of the memoranda include language relevant to the issue presented here.[9] The first is a March 6, 1979 memorandum from the Administrator to the Regional Administrators titled *Response To Energy Emergency; Implementation Of Section 110(f) of the Clean Air Act, as amended.* The memorandum includes an attachment that recommends that when a governor petitions the President, reference be made to the possibility of case-by-case disapproval by EPA. The attachment states—

> This is necessary to impress upon *States the need to make case by case findings as required by Section 110(f). If this is not done at the State level, EPA should disapprove wherever it determines that the Governor could not have made the necessary findings for the source.* (For example, suspensions of compliance schedules would generally be inappropriate since they would be unlikely to alleviate any unemployment or residential energy loss.). (emphasis added).

This passage both supports the need for case-by-case findings, but also suggests that EPA may not disapprove a suspension that lacks such findings if the governor *could have* made them. (Another lenient determination in implementing section 110(f) occurred in 1979, when EPA was willing to overlook a failure to comply with the provision in section 110(f) to provide for a public hearing prior to a governor's petition to the President. Instead, "in light of the need to respond quickly to a crisis," a hearing was required to be held *after* the declaration of emergency was issued.[10])

---

[8] See HR rep No. 294, 95th Cong, 1st Sess 202 (1977), reprinted in [1977] US Code Cong & Ad News 1077, 1281.

[9] A third memorandum dated June 19, 1979 from two assistant administrators to the Administrator titled *Supplemental Guidance Regarding Implementation of Section 110(f) of the Clean Air Act - Action Memorandum,* addressed the issue of whether price differentials among different types of fuels would be adequate justification for an emergency suspension. While not on point to the present issues, the memorandum emphasized the importance of complying with the statutory criteria for a suspension. The memorandum stated—

> On June 7, 1979, the State of New York held hearings on a request by a public utility for a Section 110(f) SIP suspension of the low sulfur fuel oil requirement. The issue before New York was not based on an actual availability of complying low sulfur fuel oil but was based on whether the high price of complying fuel oil relative to non-complying fuel oil was sufficient justification for a SIP suspension. EPA was requested by New York to provide policy guidance. . . . Price differentials between complying and non-complying fuel oils may provide a sufficient justification for a SIP suspension only when such differentials actually cause (or are anticipated to cause) the effects of an energy emergency listed in Section 110(f)(2), i.e., high levels of unemployment or a loss of necessary energy supplies for residential dwellings and such effects could be totally or partially alleviated by an emergency suspension.

[10] See Currie, *Air Pollution, Federal Law and Analysis,* §5.17 (1981). The issue arose within months of enactment of section 110(f) when a prolonged coal strike in the winter of 1977-78 reduced fuel supplies in several states. Ohio, followed by six other states, sought and received a presidential declaration of emergency. Ohio subsequently suspended sulfur oxide regulations. Later, EPA "feebly" (as stated by Currie, *id.*) explained that while this action "may

The March 6, 1979 EPA memorandum attachment goes on to recommend that EPA participate in public hearings because—

> it will give us the opportunity to establish on the record early in the process that blanket SIP suspensions throughout a State may not be acceptable and that the findings required by Section 110(f)(2)(A) and (B) of the Act must be made for each source to be covered by the suspension.

Again, this language cuts both ways, stating that blanket suspensions throughout the state *may* not be acceptable, but stating that the findings must be made for *each source*.

The second EPA memorandum dated January 10, 1980 and titled *Alternative Procedure for Section 110(f) Relief in Localized, Short Term Energy Emergencies,* was sent from two acting assistant administrators to the regional administrators. It established an expeditious process to review emergency suspensions that were to last less than 30 days. The memorandum states that a governor's petition to the president should contain—

> a brief statement of the basis for the request, including the *approximate number and types of sources affected,* the apparent cause of the emergency, efforts made to alleviate the situation through other means and why those efforts are insufficient, a summary of available information on possible unemployment and/or loss of necessary residential energy supplies, and (wherever possible) a discussion of potential air quality impacts of anticipated suspensions . . . . (emphasis added).

This language recommends refers to the "approximate number and types of sources affected," indicating the possibility of a suspension applicable to a class of sources. This discussion was, however, related to the governor's petition to the President for a declaration of emergency; it was not referring to the findings to be made by the governor.

Conclusions. Section 110(f) requires the governor to make findings of fact that apply to each source that would be covered by a suspension. The statute, its legislative history, and EPA implementing memoranda are not clear regarding whether or not a single set of findings could apply to all sources in a category, but they all contain indications that Congress intended a case-by-case determination. It is thus my opinion that the most supportable interpretation—and the one that a court is most likely to accept—is that section 110(f) requires a case-by-case determination, including findings of fact explicitly referencing and related to each source subject to an emergency suspension. I reach this conclusion primarily because of the references to particular or individual sources in the statute and its legislative history. I found nothing in the statute or legislative history to suggest that Congress intended section 110(f) to be a vehicle to grant blanket suspensions

---

not have been strictly in accordance with the procedural requirements," it was taken "in light of the need to respond quickly to a crises." *Id.*

to entire classes of sources. However, given the statutory language, which does not specifically require case-by-case findings for individual sources, and which specifies findings that could—in theory—be the same for many sources, it is by no means certain that a court would agree with this conclusion where identical findings would apply to many sources.

It is clear, however, that in the absence of a presidential declaration described in subparagraph (1)(A), or in the absence of any findings by a governor that arguably comply with the requirement described in subparagraph (2)(A), no emergency suspension may be issued.

Please call if you have any questions or need anything more.

Sincerely,

Peter M. Greenwald

Appendix I

BUGs Dispatch Report

FINAL

BUGs Dispatch Report

Deliverable to the California Energy Commission
under Agreement 500-00-032

Revised April 16, 2002

by:
Michel C. Wehrey
Energy and Transportation Solutions
Consultant to:
College of Engineering-Center for Environmental Research and Technology
University of California
Riverside, CA 92521
(909) 781-5676
(909) 781-5790 fax

02-PO-18527-2.4.1-F

Table of Contents

1. Summary

This report is submitted under Task 2.4 of Agreement 500-00-032. The purpose of Task 2.4 is to explore dispatch issues associated with backup generators (BUGs). BUGs are placed in service when an emergency situation exists (such as damage to transmission lines during a storm) or when the local utility has imposed a blackout in response to load curtailment instructions from the System Operator, the agency controlling its operation (faced with a shortfall of generation resources or transmission line capacity). When a BUG is operating, the facilities or equipment normally served by the utility are no longer connected to the grid. One or several BUGs provide power to essential facilities or pieces of equipment during the power outage and are shut down when service is restored.

The utilities require that the BUG(s) be operated in isolation from the grid for safety and power quality reasons – that is, a facility cannot receive part of its electricity from the grid and part from an on-site BUG simultaneously unless the areas of the facility served are isolated from each other or unless the facility has substantial power conditioning equipment. Regulations and codes dictate the conditions under which the BUGs can currently be installed and operated.

If a BUG were to be operated as an energy source supplementing the utility system, feeding the owner's facilities and equipment and/or utility customers in the neighborhood via the utility grid, it would become an "Independent Power Producer" or "Distributed Generation." Although this is not the original purpose of a BUG, it is conceivable that this could be a strategy for protecting against future outages. When a shortage is likely, a BUG could be dispatched in advance to provide electricity to the grid and keep the system operating. Alternatively, a central power planner could order that some BUGs be activated, either to provide power in areas where shortages are anticipated or to reduce demand on the grid.

For this scenario to be realized, a BUG operator would have to make upgrades to the system, conform to government requirements and numerous applicable national standards, and reach an agreement with the local utility. This report identifies the technical and practical issues of BUG dispatch in California. It is applicable not only to backup generators themselves, but to other forms of distributed generation, which gradually are becoming part of California's energy mix.

2. BUG Operation and Interconnection Requirements

2.1 Definitions

To understand the technicalities involved, the following definitions used by utilities and in the codes and regulations are provided:

Isolated Operation. The BUG is only connected to a portion or the whole electrical system of the owner's plant or facilities when the portion of, or the whole system, is disconnected from the utility grid. If a BUG is not certified for parallel operation, a protection device (transfer switch) has to be installed and functioning to prevent any accidental parallel (interconnected) operation of the BUG.

Parallel Operation. The BUG is connected to the owner's electrical service system (where electrical power is received from the utility) and the electrical system of the owner's plant or facilities.

"Islanding" Operation. The BUG is connected to the neighboring portion of the utility grid serving the owner's plant or facilities (which have been isolated for repair purposes) and may act as a "local" generating facility. This situation would be very dangerous and has to be prevented.

2.2 Overview of Parallel Operation

When a BUG is operated as part of an active utility grid it must meet the following operational requirements:

- Frequency control (59.3 to 60.5 Hz).
- IEEE 519 Harmonic Distortion Limit.
- Power Factor greater or equal to 0.9. If lower than 0.9, reactive power has to be provided on site.
- Synchronization needed (when connecting)
    - within .2 Hz of grid frequency.
    - within 10% of grid voltage.
    - within 10 degrees of phase angle.
- Compliance with UL1741- Utility Interactive Requirements.

To be accepted by the utility and, using the Southern California Edison example, the BUG owner/operator will go through an Administrative Process which has the following steps:

- Application completed.
- Engineering review (by utility company).
- Equipment selection and electrical drawings.
- Local permits and approvals.
- Execution of agreement (with utility).
- Installation of equipment by qualified personnel or contractor.

Typically the equipment needed will include:

- Circuit breaker.
- Synchronization monitor (manual operation).
- Synchronization device (automatic operation).
- Protection devices for (i) loss of synchronization, (ii) power factor (voltage) regulation; (iii) frequency control; and (iv) electrical faults (ground, insulation, etc.).

Some of this equipment may be integrated in the BUGs control system as it is being upgraded.

3. Review of Applicable Standards and Regulations

3.1 Regulatory and Contractual

California Energy Commission Rule 21 has been adopted by the California Public Utilities Commission. It was filed on October 21, 1999, and a Supplementary Filing was done in January 9, 2001. It defines the conditions under which independently owned electrical generation facilities can operate and was produced through a series of workshops involving the major California utilities and represents a wide consensus. The requirements of Rule 21 are listed and summarized in Section 6.

Other contractual documents, executed by the BUG owner/operator and the local electric utility, will include:

- Generation Facilities Interconnection.
- Interconnection Agreement
- Application to interconnect.

3.2 Technical and Safety

The following Standards apply to interconnected BUGs:

- IEEE P 1547 – "Standard for Interconnecting Distributed Resources with Electric Power Systems." It provides a uniform standard for interconnection of distributed resources (as BUGs intended for parallel operation now become) with electrical power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.

- The National Electric Code and the Local Building Code. They define what type of electrical wires must be used, how they must be installed, how grounding must be provided and what kind of protection devices (such as ground fault protection – GFI) have to be provided.

4. Costs of BUG Upgrades

All or some of the following upgrades (depending on the existing installation) may be required for parallel operation of BUGs. Costs are in 2002 dollars for BUGs in the 250 to 500 kW rating ranges (a widespread BUG size range). Larger units would drive the cost of the circuit breaker and wiring modifications up. Multiple units would multiply the upgrade costs although some economies of scale could occur. A detailed engineering review and request for quotation for a specific situation would be needed to validate the conceptual assumptions made. Please refer to Figure 4-1 and Table 4-1 for a typical installation.

Installation of new Circuit Breaker

Material.. 1,500

Labor.. 500

Retrofit of Synchronization Monitor

Material.. 1,500

Labor.. 500

BUG Engine Controls Upgrade

Allowance.. 5,000

Additional Protection and Metering Devices

Allowance.. 3,000

Facilities Wiring Modifications and Tie in

Allowance.. 2,000

Contingency

7%.. 1,000

Total Estimated Costs.. $15,000

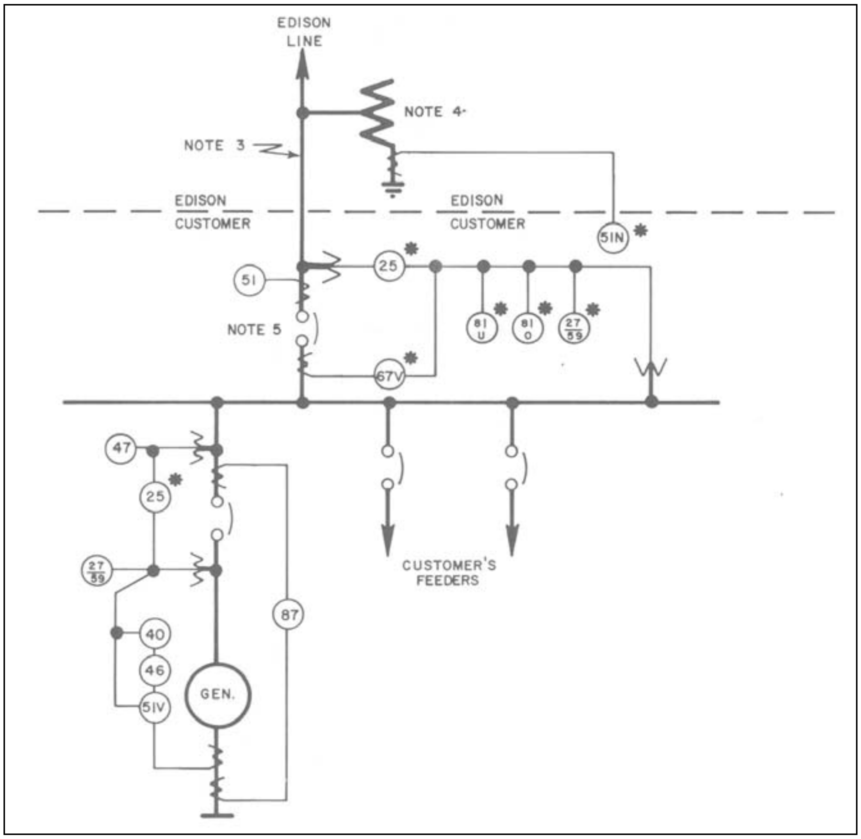


Figure 4-1. Typical parallel generation with customer protection.

Table 4-1. Protective device numbers.

4	MASTER CONTACTOR
25	SYNCHRONIZING OR SYNCHRONISM CHECK
27	UNDERVOLTAGE
32	POWER DIRECTION
40	LOSS OF FIELD DETECTION
46	CURRENT BALANCE
47	VOLTAGE PHASE SEQUENCE
51	TIME OVERCURRENT
51G	GROUND TIME OVERCURRENT
51N	NEUTRAL TIME OVERCURRENT
51V	VOLTAGE RESTRAINED/CONTROLLED TIME OVERCURRENT
59	OVERVOLTAGE
59G	OVERVOLTAGE TYPE GROUND DETECTOR
67V	VOLTAGE RESTRAINED/CONTROLLED DIRECTIONAL TIME OVERCURRENT
79	RECLOSING RELAY
810	OVERFREQUENCY
81U	UNDERFREQUENCY
87	CURRENT DIFFERENTIAL

5. Potential BUG Dispatch Limitations

The dispatching (selection and request for operation) of BUGs may be prevented by the electricity transfer capabilities of distribution lines (4, 12 and 16 kilovolts), subtransmission lines (66 and 115 kilovolts), and transmission lines (250 and 500 kilovolts). Figure 5-1 illustrates this situation at regional levels between large loads and large generation centers.

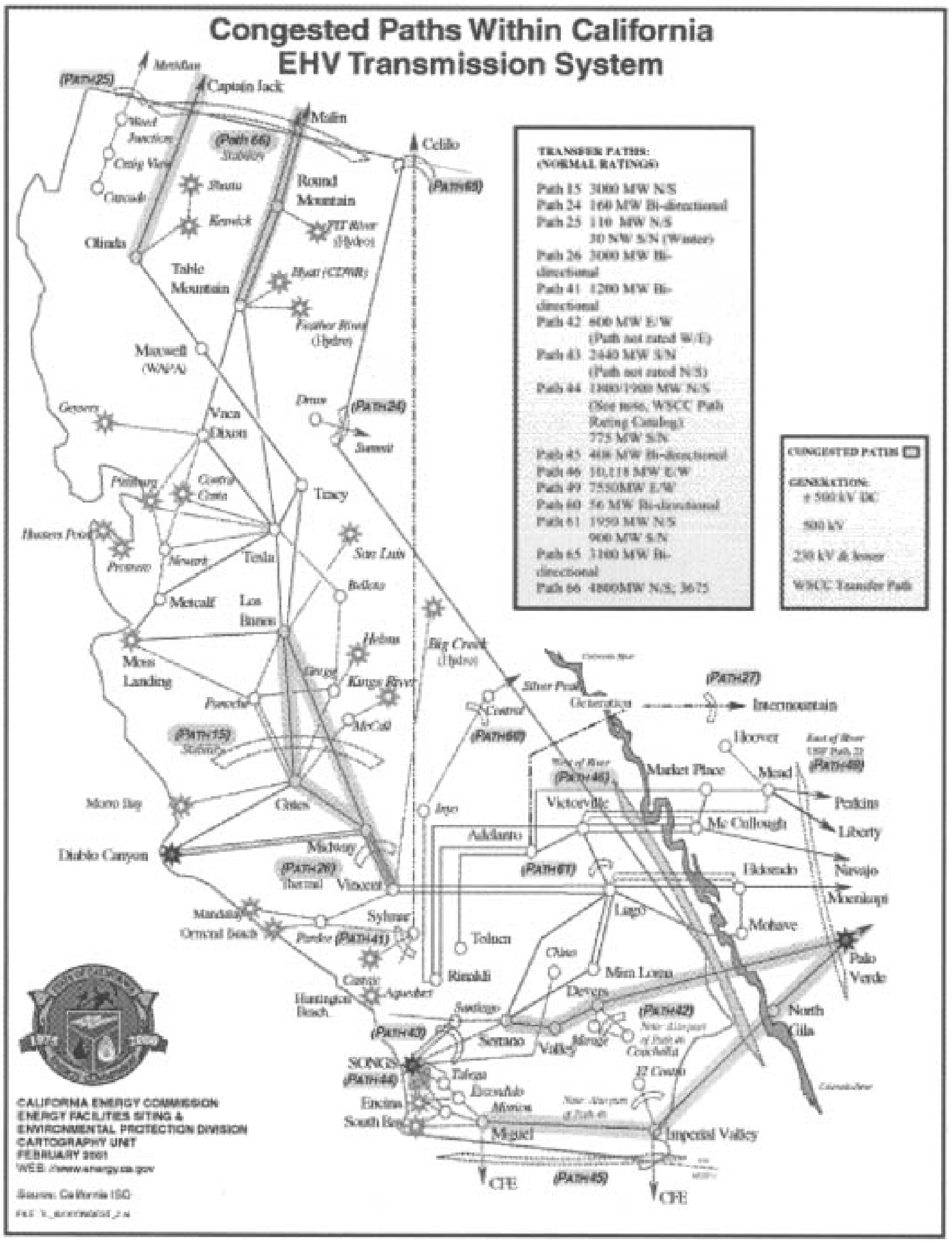


Figure 5-1. Map of California distribution system, showing "choke points" that supplies may not be able to cross.

Load and energy flow studies (computer modeling) routinely performed by utility planners and system operators will be needed to determine the conditions under which BUGs can feed electricity to a section of a particular grid.

Distribution, subtransmission or transmission line upgrades may have to be implemented. These upgrades could involve larger conductors, additional lines, larger transformers, additional or larger switching equipment, etc.

Utilities constantly monitor the performance of their system and determine the most cost-effective methods of meeting new customer or system operator demands.

6. Rule 21 Overview

Rule 21 was finalized in 2000 during a series of workshops coordinated by the California Energy Commission. A consensus was reached by the main utilities in the State (PG&E, SCE, SDG&E), and new technical and administrative requirements for "Interconnected Generation Facilities" were published. It was filed under Advice 1498 – E – A.

It covers the topics listed and summarized below.

A – **Applicability**: Interconnection, operating and metering requirements for Generating Facilities to be connected to the SCE (or PG&E, or SDG&E) Distribution System over which the Public Utilities Commission has jurisdiction.

B – **General Rules, Rights, Obligations**: Include Authorization Required to Interconnect, Separate Arrangements Required for Other Services, Transmission Service Not Provided with Interconnection, Compliance with Laws, Rules and Tariff Schedules, etc.

C – **Generating Facilities Application and Interconnection Process**: Applicant initiates contact with SCE (or PG&E, or SDG&E), Applicant completes an application, etc.

D – **Interconnection Facilities**: General Interconnection and Protection Requirements, Prevention of Interference, Control, Protection and Safety Equipment Requirements, etc.

E – **Interconnection Facilities Ownership and Financing**: Scope and Ownership of Interconnection Facilities, Responsibilities of Costs of Interconnecting a Generation Facility, etc.

F – **Metering, Monitoring and Telemetry**: General Requirements, Metering by non-SCE (or PG&E, or SDG&E) parties, Net Generation Metering, Point of Common Coupling Metering (bi-directional meter), Telemetering, Sunset Provision, etc.

G – **Dispute Resolution Process**: The Public Utilities Commission shall have initial jurisdiction to interpret, add, or modify any provision of this Rule.

H – **Definitions**: "Accredited National Recognized Testing Laboratory," "Active Anti-Islanding Scheme," "Applicant," etc.

I – **Initial Process for Application to Interconnect Facilities**: Developed to create a path for selection and rapid approval for the interconnection of those generating facilities that do not require an Interconnection Study, i.e. use approved equipment, have capacity less than 11 kVA, etc.